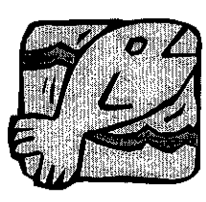
6. Biological Environment

6.1 Fisheries and Aquatic Ecosystems

The CALFED Bay-Delta Program is expected to achieve recovery of the listed and proposed fish species found in the Delta, and to support and enhance sustainable populations of diverse and valuable aquatic species (such as chinook salmon, steelhead, delta smelt, splittail, striped bass, and sturgeon) through actions that improve and increase aquatic habitat and improve ecological processes in the Bay-Delta.



6.1 Fisheries and Aquatic Ecosystems

6.1.1 SUMMARY

Aquatic ecosystems in the Bay-Delta support important recreational and commercial fisheries worth millions of dollars and provide substantial intangible cultural, scientific, and social value. The role of aquatic species in ongoing conflicts over beneficial uses of water in the Bay-Delta ecosystem is testimony to their value, especially for species listed under the Endangered Species Acts (ESAs). Conserving the values provided by aquatic species for future generations requires maintenance and enhancement of ecosystem health concurrent with existing and increasing human demands for water supply, flood control, and other aquatic ecosystem functions.

The role of aquatic species in ongoing conflicts over beneficial uses of water in the Bay-Delta ecosystem is testimony to their value.

All Alternatives. Fisheries and the aquatic ecosystem would benefit from implementation of many elements included in the CALFED Bay-Delta Program (Program) alternatives. The Ecosystem Restoration Program would reactivate and maintain ecological processes and structures that sustain healthy fish, wildlife, and plant populations. The program also is expected to increase the abundance and distribution of desired aquatic species, possibly including delta smelt, sturgeon, splittail, chinook salmon, and steelhead. Aquatic species would benefit from improved and reestablished ecosystem processes, including streamflow, sediment supply, floodplain connectivity, stream temperature, and biological productivity. Restoration of aquatic areas through levee setbacks and other actions would increase species habitat, and new fish screens would reduce entrainment losses. Actions to improve harvest and artificial propagation management would rehabilitate naturally producing fish populations.

The Levee System Integrity Program would reduce the risk of catastrophic levee failure, reducing the likelihood of the resulting rapid hydrodynamic and salinity changes that could adversely affect species habitat abundance, movement, and losses to diversions. Levee maintenance and construction practices (for example, setback of levees and construction of channel-side berms) would allow development of aquatic and riparian communities, subsequently providing habitat for Delta species.

The Water Quality Program would reduce input of contaminants to the system, resulting in improved productivity and species survival, growth, and reproductive success. Aquatic species in the Sacramento River and San Joaquin River systems, the Delta, and the Bay would benefit from reduced metabolic stress.

New storage allocated to environmental water supplies and water acquisitions for environmental uses could benefit aquatic species through enhancement of seasonal flow needs, potentially improving water temperature conditions and increasing habitat abundance. New storage and implementation of the Water Use Efficiency and Water Transfer Programs, combined with increased operational flexibility, could allow flow management that would improve water temperature and other flow-related habitat conditions for aquatic species. Although potentially reducing storage yield, entrainment losses also could be minimized through change in the timing of diversions to periods when species vulnerability is low. Under the Watershed Program, activities are expected to improve water quality and flow conditions in the upper watershed, potentially improving species habitat in downstream areas through reduced contaminant input, cooler water temperature, and flow conditions that more closely meet species needs.

Some of the elements included in the Program could adversely affect fish and the aquatic ecosystem. In most cases, however, implementation strategies and mitigation would be developed and implemented to reduce adverse impacts to less-than-significant levels. Construction-related adverse impacts would be avoided and minimized though implementation of BMPs. Restoration of habitat would consider species needs relative to structure, seasonal availability, and stressors where stressors include contaminants, diversions, and impaired ecosystem processes—such as flow, temperature, sediment movement, and nutrient input.

Some potential adverse impacts may be significant and unavoidable. Habitat restoration, given the existing hydrologic and hydraulic conditions, and the existing altered biological community structure, may adversely affect native species. Newly created habitat may increase the abundance of non-native species, potentially increasing competition and predation on native species. Increased urban and industrial development in response to more reliable water deliveries may increase contaminant input and the incidence of human-caused disturbance to aquatic communities.

Preferred Program Alternative. Elements of the Preferred Program Alternative with substantial uncertainty relative to impacts on fish and aquatic resources include the pilot diversion facility near Hood, setback levees or dredging along the Mokelumne River channel and Old River, and south Delta barriers. The components have the potential to provide substantial benefits through increased operational flexibility, creation of habitat, and improved Delta flow conditions. Because of uncertain species responses to the Program elements, the potential also exists for adverse impacts. Uncertainty must be addressed and Program elements would be constructed and operated only after information clearly confirms that potentially significant adverse effects on fish and aquatic species populations can be avoided. Key to implementation of the Preferred Program Alternative is a strategy to address the uncertainty of species and ecosystem responses to Program elements. Ongoing activities to increase understanding of natural physical and biological processes and species habitats include the Strategic Plan for the Ecosystem Restoration Program (Strategic Plan), the Comprehensive Monitoring and Research

Components of the Preferred Program Alternative have the potential to provide substantial benefits through increased operational flexibility, creation of habitat, and improved Delta flow conditions. Because of uncertain species responses to the Program elements, the potential also exists for adverse impacts.

Program (CMARP), and development of a Multi-Species Conservation Strategy (Conservation Strategy).

Beneficial effects of habitat restoration for native species may be assured through consideration of species habitat needs relative to structure, seasonal availability, and stressors. Conditions needed to minimize value to undesirable non-native species would be identified.

To minimize and avoid potential adverse effects of changes in flow and diversion, construction and operation of new facilities, such as barriers, fish screens, and conveyance channels, may be preceded by focused studies to determine the environmental effects, including species population response. Actions may be implemented progressively over the long term, and actions would be integrated with monitoring and evaluation to assess effects on the aquatic ecosystem, achievement of the Program objectives, and conformance to Program solution principles. Potential operations flexibility provided through coordination with existing water supply system components and other Program elements, such as the Water Use Efficiency, Water Transfer, and Watershed Programs and Storage would be identified.

To minimize and avoid potential adverse effects of changes in flow and diversion, construction and operation of new facilities, such as barriers, fish screens, and conveyance channels, may be preceded by focused studies to determine the environmental effects, including species population response.

Although adverse effects on aquatic species population would be avoided, harm to individual organisms could result from certain aspects of the Program elements (for example, entrainment loss and migration delay). For special-status species, such as species listed under federal and California ESAs, harm to individual organisms and their habitat is considered a potentially significant adverse impact. The Program has committed to developing mitigation strategies that will minimize potentially significant adverse impacts prior to construction and operation of Program elements.

Alternatives 1, 2, and 3. Changes in Delta flow conveyance facilities and channels could benefit Delta species. DCC operations (under Alternatives 2 and 3) and the south Delta barriers would increase survival of juvenile chinook salmon entering the Delta from the Sacramento and San Joaquin Rivers. New SWP and CVP fish screens would reduce entrainment losses of all species relative to conditions under the No Action Alternative or existing conditions. Setback levees along the Mokelumne and Old River channels are expected to increase riparian and tidal marsh communities, and provide additional habitat for Delta aquatic species. Relocation of the SWP intake on Clifton Court Forebay (CCFB) would reduce entrainment losses from the south and central Delta. Under Alternative 3, relocation of the intake would increase the frequency and magnitude of natural net channel flow in the south and central Delta, potentially reestablishing conditions that would increase productivity, enhance species movement, and reduce entrainment in Delta diversions.

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Substantial uncertainty relative to impacts on fish and aquatic resources is associated with the diversion facility near Hood, set back levees or dredging along the Mokelumne River channel and Old River, and south Delta barriers. Potentially significant unavoidable adverse impacts may occur that would potentially limit restoration options and success discussed for other elements of the alternatives. Placement of barriers in the south Delta and at Hood under Alternative 2 may block access to habitat, and alter water quality and flow conditions. Under Alternatives 2 and 3, the diversion facility near Hood and fish screen may increase fish mortality through abrasion, increased predation, and delayed migration. The Hood diversion would also reduce flow in the Sacramento River, potentially reducing survival and degrading habitat conditions for species downstream of the diversion. Changes in operations and diversion locations under Alternative 3, including relaxation of current SWP pumping restrictions that allow use of the full 10,300-cfs pumping capacity, may reduce or otherwise alter flow conditions in the Delta, potentially reducing system productivity, impairing species movement, increasing losses to diversions, and reducing habitat abundance.

The following table presents the potentially significant adverse impacts and mitigation strategies associated with the Preferred Program Alternative. Mitigation strategies that correlate to each listed impact are noted in parentheses after the impact.

Potentially Significant Adverse Impacts and Mitigation Strategies Associated with the Preferred Program Alternative

Potentially Significant Adverse Impacts

Potential increased non-native species abundance and distribution to levels detrimental to native species from reestablishment of aquatic areas (4,9).

Potential blocked access to habitat and potentially altered water quality and flow conditions from placement of barriers in the south Delta (3,5).*

Potential altered natural ecosystem structure, removal of benthic communities, and creation of conditions that may damage habitat for desired species from dredging activities (1,2,3).

Potential short-term disturbance of existing biological communities and species habitat, mobilized sediments, and input contaminants from construction activities (1,2).

Potential reduced streamflow and Delta outflow, changed seasonal flow and water temperature variability from water supply management, and changes in salinity associated with several Program elements—potentially resulting in reduced habitat abundance, impaired species movement, and increased loss of fish to diversions (5,9).*

Potential increased entrainment loss of chinook salmon and other species from diversions to new off-stream storage (5,6,7,9).

Potential reduced frequency and magnitude of net natural flow conditions in the south and central Delta (potentially reducing system productivity, impairing species movement, and increasing losses to diversions) from DCC operations and south Delta barriers (5,9).*

Potential for reduced net flow conditions in the Sacramento River downstream of Hood (potentially reducing fresh-water area and affecting species movement and survival) from the through-Delta element (5,8,9).*

Potential increased fish mortality through abrasion, increased predation, and other factors from the new fish screen facility for the through-Delta element on the Sacramento River (5,7,8,9).*

Potential delayed migration and reduced spawning success for adult fish moving from the Mokelumne River channels into the Sacramento River from fish screens and a diversion facility on the through-Delta element (5).*

Mitigation Strategies

1. Implementing BMPs, including a stormwater pollution prevention plan, toxic materials control and spill response plan, and vegetation protection plan.
2. Limiting construction activities to windows of minimal species vulnerability.
3. Creating additional habitat for desired species, including increasing aquatic area and structural diversity through construction of setback levees and channel islands.

Potentially Significant Adverse Impacts and Mitigation Strategies
Associated with the Preferred Program Alternative
(continued)

4. Controlling undesirable non-native species.

5. Operating new and existing diversions to avoid and minimize effects on fish (avoiding facility operations during periods of high species vulnerability). The operational changes could reduce water availability for other beneficial uses identified in Section 5.1, "Water Supply and Water Management."

6. Locating the diversion point to avoid primary distribution of desired species.

7. Controlling predators in the diversion facility (screen bays) and modifying diversion facility structure and operations to minimize predator habitat.

8. Constructing a barrier to fish movement on Georgiana Slough. Adverse impacts of a flow barrier, however, would need to be considered.

9. Coordinating and maximizing water supply system operations flexibility consistent with seasonal flow and water temperature needs of desired species.

Bold indicates a potentially significant and unavoidable impact.

* Potentially significant unavoidable impacts of the Preferred Program Alternative on fish and other aquatic species populations would be avoided through adherence to the Program implementation strategy discussed in the text and included in the Multi-Species Conservation Strategy. The asterisk identifies potentially significant impacts that reflect potential harm to individual organisms of special-status species.

6.1.2 AREAS OF CONTROVERSY

Under CEQA, areas of controversy involve factors that are currently unknown or reflect differing opinions among technical experts. Unknown information includes data that are not available and cannot readily be obtained. The opinions of technical experts can differ, depending on which assumptions or methodology they use. Below is a brief description of the areas of controversy for this resource category. Given the programmatic nature of this document, many of these areas of controversy cannot be addressed; however, subsequent project-specific environmental analysis will evaluate these topics in more detail.

Aquatic species, especially species listed and proposed for listing under California and federal ESAs, are key factors in ongoing conflicts over beneficial uses of water in the Bay-Delta ecosystem. It should not be surprising that areas of controversy arise over uncertainty in the relationships that link potential species responses to implementation of Program elements. For many relationships used in this impact assessment, alternative species responses could reasonably be expected.

It should not be surprising that areas of controversy arise over uncertainty in the relationships that link potential species responses to implementation of Program elements.

Because Program elements and mitigation actions may or may not result in the expected or desired effect on species restoration and maintenance, the environmental, economic, and social cost of implementing specific actions requires measures to resolve controversy. The following sections discuss (1) the sources of uncertainty in relationships that are contributing to controversy, and (2) the ongoing Program processes that are addressing the uncertainty of species and ecosystem responses to implementation of Program elements.

Uncertainty in the Assessment. The assessment relationships link Program actions to outcomes for species and ecosystems. Ecosystem relationships encompass fundamental ecological processes and structures (such as flow, sediment input and movement, and productivity) that contribute to the well-being of species. For ecosystem relationships, progressing toward the natural condition was assumed beneficial to native species because native species lived and evolved in a system undisturbed by human activities.

Uncertainty in the relationships applied in this impact analysis occurs because environmental problems are extraordinarily complex.

Uncertainty in the relationships applied in this impact analysis occurs because environmental problems are extraordinarily complex. At the ecosystem level, uncertainty about relationships is attributable to:

- Incomplete knowledge about the natural system relative to highly modified existing structure and processes.
- Limited understanding of inter-relationships between ecosystem processes and structure, especially relative to historical changes to ecosystem structure or processes that are irreversible and potentially limiting to restoration or reestablishment of processes and structure.
- Unpredictability of environmental change in light of growing demands on Bay-Delta resources and additional land use disturbances in the watershed.
- Lack of expert consensus about the relative importance and effectiveness of different kinds of actions in restoring the ecosystem.

For species, uncertainty is attributable to:

- Incomplete knowledge of species needs relative to factors that limit population abundance and production.
- Unpredictability of species response to environmental change.
- Lack of expert consensus about the relative effectiveness of different actions in increasing species abundance.

The relationships used in this impact assessment clearly involve a substantial degree of uncertainty associated with the link between Program actions to outcomes for species abundance. The assessment, therefore, attempts to err toward the conservative. Where adverse impacts may occur, they are identified, and appropriate mitigation strategies are proposed (see the comparison of Program alternatives to the No Action Alternative in Sections 6.1.8 and 6.1.9, and mitigation strategies in Section 6.1.12). Resolution of uncertainty in the relationship prior to implementing project actions could counter initial assessment conclusions and negate the need for mitigation.

Addressing Uncertainty. Several ongoing Program activities will address the uncertainty of species and ecosystem responses through increased understanding of natural physical and biological processes and species habitats. Ongoing activities include the Strategic Plan for the Ecosystem Restoration Program, the CMARP, and the Multi-Species Conservation Strategy.

The Strategic Plan is intended to guide the implementation of the Ecosystem Restoration Program actions for rehabilitation of the Bay-Delta system, including the recovery and maintenance of native species. The Strategic Plan has eight elements: (1) clear and measurable goals and objectives; (2) an ecosystem approach that integrates environmental, economic, and social issues; (3) adaptive management; (4) conceptual models that define linkages between management actions and resource response; (5) staged implementation of the Ecosystem Restoration Program in coordination with other Program elements; (6) a strategy for compliance with regulations and legislative mandates; (7) external scientific, professional, and public review of Program objectives and results; and (8) a system to resolve disputes between conflicting interests where species or ecosystem recovery is at stake.

The Strategic Plan is intended to guide the implementation of the Ecosystem Restoration Program actions for rehabilitation of the Bay-Delta system, including the recovery and maintenance of native species.

Adaptive management is key to the Strategic Plan and involves treating actions as experiments, deliberately taking the opportunity to learn from each management action so as to improve the process of management over time. The CMARP clearly has a critical role in adaptive management and will provide the necessary monitoring and evaluation of Ecosystem Restoration Program projects.

The development of a Conservation Strategy will serve to protect species and habitats to ensure that the Program complies with the federal and state ESAs, and the Natural Communities Conservation Planning Act. A strategy for compliance and assurances will be developed within the adaptive management framework, including open communication concerning endangered species issues.

Uncertainty of species and ecosystem responses to environmental changes resulting from implementation of all Program elements may be appropriately addressed through an adaptive management strategy. Adaptive management entails making decisions based on the best available analyses and modeling, being clear about restoration objectives relative to the ecosystem and species, designing actions that help distinguish between alternative relationships that link potential species responses to implementation of Program elements, and monitoring and evaluating the effects of Program actions (that is, the CMARP). Additional components required to address uncertainty associated with substantive actions could include:

Uncertainty of species and ecosystem responses to environmental changes resulting from implementation of all Program elements may be appropriately addressed through an adaptive management strategy.

- Clear statement of restoration goals and objectives (tangible and measurable), including geographic scope and time scale.
- Completion of a screening and prioritization process that incorporates scientific, professional, and public review and is based on the best available understanding of natural physical and ecosystem processes and species habitat needs.
- Clear separation of scientific and technical issues from societal and economic issues.

- Progressive implementation of elements included in the Program over the long term and integration with monitoring and evaluation to assess achievement of the Program objectives and conformance to solution principles.

- Targeted research or pilot projects to address high uncertainty and to demonstrate feasibility or ecosystem and species response.

The Program's position on fisheries and aquatic ecosystems is expressed in the Program mission statement and objective, which is presented in Chapter 1.

6.1.3 AFFECTED ENVIRONMENT/ EXISTING CONDITIONS

The vast watershed encompassing mountain streams, Central Valley rivers, the Delta, and San Francisco Bay supports an important array of aquatic ecosystem values, including biological communities and individual species. Human-induced changes in the ecosystem have substantially degraded natural productivity, biodiversity, and ecological integrity. The following section summarizes historical changes leading to existing conditions.

Over 200 fish species occur in the Sacramento-San Joaquin River system, the Delta, and the Bay—most of which are marine species. Over 40 species commonly occur within the Delta and upstream fresh-water environments. Although the impact assessment considers overall ecosystem health, the assessment also focuses on fish species that occur in the Delta during at least some portion of their life cycle and are listed or proposed for listing under the federal ESA. These species include winter-, spring-, fall-, and late fall-run chinook salmon; steelhead; delta smelt; and splittail.

Detailed information on the life history, historical population abundance, and factors affecting production for specific species can be found in the March 1998 Fisheries and Aquatic Resources Technical Report. Most of the species discussed have suffered declining populations in response to direct loss of spawning and rearing habitat, environmental degradation (for example, degraded water quality, altered hydrology, and diversions), barriers to migration, historical commercial fisheries, sport fisheries, and competition with non-native species.

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6.1.3.1 DELTA REGION

Historically, wetlands dominated land cover throughout the Delta, but levee construction and channelization eliminated over 95% of the original tidal wetlands and many miles of sloughs. The Delta consisted of backwater areas, tidal sloughs, and channel networks that supplied and drained highly productive tidal-marsh and wetland complexes. The marsh vegetation, in turn, supplied the Delta aquatic system with an abundant source of coarse organic matter. Marsh vegetation also slowed the movement of water through the Delta during floods, increasing hydraulic residence times and the opportunity for nutrients to be consumed.

The Delta Region includes the tidally influenced aquatic areas from the Sacramento River at the confluence with the American River and the San Joaquin River at Vernalis downstream to Chipps Island. The total surface area of the Delta area is approximately 678,200 acres, most of which is irrigated cropland. A lesser portion consists of riparian vegetation, wetlands, and other forms of "idle land." The remaining portion is occupied by channels, sloughs, and other open water. Under existing conditions, most of the open water is deep-channel habitat that has been modified to provide passage for ocean-going vessels as well as efficient conveyance of fresh water from the Sacramento River through the Delta. Vegetation is removed from levees, primarily to facilitate inspection, repair, and flood fighting when necessary. Although current flood protection programs may allow for properly managed vegetation, the amount of shallow water and shaded riverine habitat throughout the Delta is much lower now than it was historically, largely having been replaced by a patchwork of agricultural islands and revetted levees.

The Delta consisted of backwater areas, tidal sloughs, and channel networks that supplied and drained highly productive tidal-marsh and wetland complexes. The marsh vegetation, in turn, supplied the Delta aquatic system with an abundant source of coarse organic matter.

The bulk of the total fresh-water inflow to the Delta originates from the Sacramento River, and most of the total inflow occurs during winter and early spring. Compared to historical conditions, the average residence time of Delta water, nutrients, algae, and other forms of fine particulate organic matter has been greatly reduced by flow changes caused by channelization and diversions. Varying portions of the inflow are diverted under different conditions. Thus, at certain times, the amount of water, sediment, and nutrients flowing out of the Delta to Suisun Bay is greatly reduced. Agricultural, municipal, and industrial diversions directly remove fish, invertebrates, and nutrients from the system. Migration of adult and juvenile fish is affected by flow, temperature, dissolved oxygen, chemical cues, and physical barriers. Reverse flows in Delta channels caused by diversion operations may adversely affect migrating fish species and movement of planktonic larvae to nursery areas, by confusing migrants and delaying migration or lengthening the migration routes. Reverse flows and loss of algae and other food resources have contributed to the reduction of Bay-Delta productivity and of some Bay-Delta invertebrate and fish populations.

Compared to historical conditions, the average residence time of Delta water, nutrients, algae, and other forms of fine particulate organic matter has been greatly reduced by flow changes caused by channelization and diversions.

The rivers flowing into the Delta, together with agricultural return flows and urban wastewater flows in the Delta, transport contaminants in addition to water, sediment, and nutrients. Some contaminants arrive in dissolved forms but most, such as trace metals, a number of herbicides, and other synthetic organic toxicants, are transported in association with fine particulate sediment and organic matter. It is known that some contaminants accumulate within the foodweb, adversely affecting productivity and species abundance. The concentration in fish or other high-trophic-level organisms can be orders of magnitude greater than concentrations in the water or in algae, invertebrates, and other lower-trophic-level organisms.

The rivers flowing into the Delta, together with agricultural return flows and urban wastewater flows in the Delta, transport contaminants in addition to water, sediment, and nutrients.

With millions of acre feet of water stored and diverted upstream of the Delta, and millions more diverted from the Delta, winter and spring flows through the Delta are substantially reduced relative to natural conditions. In many years, annual Delta outflow may be reduced by 30-60% relative to natural runoff. Delta flow affects the abundance and distribution of many species, and diminished flows have likely reduced species productivity in some years.

With millions of acre feet of water stored and diverted upstream of the Delta, and millions more diverted from the Delta, winter and spring flows through the Delta are substantially reduced relative to natural conditions.

Introduced fish and macro-invertebrate species currently dominate the biological community of the Delta. Along with changes in sources, composition, and amounts of nutrients, introduced species have substantially modified Delta food webs relative to historical conditions. Although extremely difficult to substantiate, changes in the food web have undoubtably reduced the productivity of some species.

6.1.3.2 BAY REGION

The Bay Region extends downstream from Chipps Island to the Golden Gate Bridge and includes aquatic habitat in Suisun Marsh, Suisun Bay, San Pablo Bay, Central Bay, and South Bay. Shoals and mudflats cover most of the surface area of the Bay, whereas most of the Bay's volume is contained within deep, fairly narrow channels that are dredged periodically to maintain shipping lanes for ocean-going cargo vessels. From an ecosystem standpoint, the Bay functions as a temporary storage, mixing, and processing basin for fresh water, sediment, nutrients, and food resources flowing out of the Delta. The first embayment to receive these resources is Suisun Bay, including Suisun Marsh, a critical food production and food consumption area of the Bay Region aquatic ecosystem. Because of its highly dynamic and complex environmental conditions, the Bay estuary supports an extraordinarily diverse and productive ecosystem that serves as a critical rearing area for resident and anadromous fish.

Because of its highly dynamic and complex environmental conditions, the Bay estuary supports an extraordinarily diverse and productive ecosystem that serves as a critical rearing area for resident and anadromous fish.

Wetlands and related habitat are some of the most valuable natural resources in the Bay and Suisun Marsh. Most of the mudflats, tidal and seasonal marshes, and riparian woodland have been reduced by 50-80% over the past 140 years, primarily as a result of urban and agricultural development. Large areas that were once tidal marsh habitat have been transformed into salt ponds and agricultural land, reducing the shallow-water habitat available to fisheries resources. In addition, the Bay's open-water area has diminished by one-third, with wetland and riparian wildlife habitats eliminated or degraded. Seasonal stormflows have increased, and sediment and nutrient transport processes changed in the estuarine ecosystem. Past projects have decreased the surface area of the San Francisco Bay by 37%, and removed valuable habitat for aquatic and terrestrial organisms.

Where fresh water and sea water mix in Suisun Bay, high zooplankton populations develop, on which many estuarine resident and anadromous fish depend. The deterioration of the zooplankton community and its algal food supply in critical habitat areas of the Bay Region is considered a serious problem because striped bass, delta smelt, chinook salmon, and other species that use Suisun Bay and the Delta as a nursery area feed almost exclusively on zooplankton during early stages of their life cycles.

Where fresh water and sea water mix in Suisun Bay, high zooplankton populations develop, on which many estuarine resident and anadromous fish depend.

Much of the plant biomass and other forms of organic matter consumed by zooplankton in the Bay Region is not produced in the Bay but is transported in from the Sacramento and San Joaquin Rivers, and accumulates in Suisun Bay and the west Delta. The proportion of the organic material imported to or produced within and upstream of the Delta that reaches Suisun Bay varies considerably from year to year and depends, in part, on prevailing flow conditions. As indicated for the Delta, annual outflow in many years has been reduced by 30-60% relative to natural runoff. At higher flows, much of the organic material brought in by the rivers would travel to Suisun Bay or to San Pablo and central San Francisco Bays. At low flows, more biological production remains in the Delta. Reduced flows likely reduces the transport of organic material to the Bay in some years.

The Bay-Delta foodweb has changed in recent years, especially as algae abundance has declined in Suisun Bay. Low chlorophyll levels in Suisun Bay coincide with very low Delta outflow during the drier years (such as in 1977, 1987, and 1992) and high outflow in the very wet years (such as in 1983 and 1995). In some wet years, some of the algae biomass in Suisun Bay is washed downstream into the wider expanses of San Pablo Bay. Many native aquatic invertebrate species have become less abundant or more narrowly distributed, while dozens of new, non-native species have become well established and widely dispersed. In general, the abundance of plankton has declined, while populations of many bottom-dwelling invertebrates, most notably introduced Asian clams, have increased. This transition has been most evident in Suisun Bay.

Contaminants enter the Bay with stormwater runoff, from hundreds of municipal and industrial discharges, and from the Delta. The decline of fish and zooplankton populations in the Bay Region may be a result, at least in part, of the effects of heavy metals, herbicides, pesticides, and other toxic substances. Very low concentrations of these substances in the water column may act individually or in combination to reduce productivity. Substantial recent improvements in treatment have substantially reduced contaminant problems, although urban runoff remains a considerable source of contamination.

Most of the tributary streams in the Bay Region have lost habitat through channelization, riparian vegetation removal, reduced water quality, and the construction of fish barriers. The fish of the tributary streams of the Bay are sensitive to changes in habitat, and reduced fish abundance in these streams generally reflects the intensity of urbanization of the surrounding lands.

Most of the tributary streams in the Bay Region have lost habitat through channelization, riparian vegetation removal, reduced water quality, and the construction of fish barriers.

6.1.3.3 SACRAMENTO RIVER REGION

The Sacramento River Region encompasses aquatic habitat in the major stream reaches in the Sacramento River basin. The major reservoirs (reservoirs that provide flood control and water storage) on the Sacramento River and its tributaries also are included in this region. The March 1998 Fisheries and Aquatic Resources Technical Report describes each of the streams and reservoirs in the Sacramento River Region.

Historically, wetlands covered an estimated 1,400,000 acres of the Sacramento Valley. These wetlands were comprised of mostly riparian forests and semi-permanently flooded tule marshes. Currently, approximately 170,000 acres of wetlands remain and are dominated by tule marsh. In addition, a large portion of agricultural lands are subject to flooding during wet years. Some 500,000 acres of riparian forest historically fringed the entire length of the mainstream Sacramento River channel. Today, less than 5% of the mainstream riparian forest remains. As in the Delta, wetland plants and riparian forests provided food and shelter for aquatic biota and greatly increased the hydraulic residence time of the system.

Under existing conditions, most of the acreage adjacent to the river is protected by levees, and long sections of the river have been straightened to maximize agricultural land and improve channel conveyance capacity. On the Sacramento River, the section from Chico Landing to the Delta is contained within levees. Consequently, the frequently inundated floodplain currently is limited to a narrow terrace. Miles of meanders, backwaters, and sloughs have been eliminated; and less than 5% of historical wetlands remains. As in the Delta, levees are reinforced and kept relatively free of vegetation, measures that have greatly reduced the occurrence of sloughs and side channels, the supply of organic material, and the quality of invertebrate and fish habitat in the river ecosystem.

Under existing conditions, most of the acreage adjacent to the river is protected by levees, and long sections of the river have been straightened to maximize agricultural land and improve channel conveyance capacity.

Much of the annual runoff volume of the Sacramento River system is stored in reservoirs; therefore, Sacramento River and tributary flows are highly regulated and under the direct control of Reclamation, DWR, and others. The main purposes of the reservoirs are flood control and storage for subsequent release to downstream diverters and generation of electricity. Relative to the natural flow regime, the present river flows are lower in spring and winter but higher in summer and fall. Spring flows have been reduced by more than 50% in some years, attributable to both reservoir operations and diversions. Hundreds of diversions entrain fish and nutrients with diverted water, removing productivity from the river system.

Relative to the natural flow regime, the present river flows are lower in spring and winter but higher in summer and fall.

The dams creating reservoirs block access to over 80% of spawning and rearing habitat historically available to chinook salmon and steelhead. The reservoirs also function as settling basins for all of the coarse sediment and organic material, and a large fraction of the fine sediment brought in by inlet streams. Sediment movement diminished by the reservoirs has degraded downstream spawning and rearing habitat. The major reservoirs have low nutrient levels and support modest phytoplankton production. Algal biomass and fine particulate organic matter derived from terrestrial vegetation form the basis of the foodweb in the downstream river ecosystems. Planktonic algae abundance is generally low because residence time is short and relatively high amounts of suspended sediment prevent light penetration.

Reservoir operations, removal of riparian vegetation, agricultural drainage, and channel modification have created water temperature conditions that adversely affect species habitat below reservoirs. In addition, loss of riparian and floodplain habitat have reduced nutrient inputs. In combination with changes in flow and introduction of new species, natural food webs have been altered and native species eliminated or their abundance substantially reduced.

Reservoir operations, removal of riparian vegetation, agricultural drainage, and channel modification have created water temperature conditions that adversely affect species habitat below reservoirs.

Inactive and abandoned mines discharge acid mine drainage into the upper Sacramento River and tributaries. This drainage contains trace metals, especially copper and zinc, that are toxic to aquatic organisms. Abandoned mines and natural erosion in other parts of the catchment contribute mercury. Urban runoff and municipal and industrial discharges are sources of metals and organochlorine compounds that can accumulate in fish and other high-trophic-level aquatic organisms. Agricultural return flows also discharge potentially harmful herbicides and pesticides into the system, as well as increasing turbidity through input of fine sediments.

6.1.3.4 SAN JOAQUIN RIVER REGION

The San Joaquin River Region encompasses aquatic habitat in the major stream reaches in the San Joaquin River basin. Human-induced changes discussed for the Sacramento River Region also have occurred in this region. Major reservoirs include San Luis Reservoir and dozens of reservoirs on the San Joaquin River and its tributaries. The aquatic system, as in the Sacramento River, consists of a mainstream San Joaquin River and its major tributaries—the Stanislaus, Tuolumne, and Merced Rivers—and several hundred small tributary streams. The Mokelumne, Cosumnes, and Calaveras Rivers are considered in this region, although these rivers could more appropriately be considered as independent Delta tributaries. The March 1998 Fisheries and Aquatic Resources Technical Report describes each of the streams and reservoirs in the San Joaquin River Region. The region encompasses approximately 10.2 million acres, of which approximately one-third is the San Joaquin Valley. Approximately one-fifth of the region supports irrigated agriculture, whereas only a small portion of the area is urban.

Precipitation in the San Joaquin River basin is less than that in the Sacramento River Region. Snowmelt runoff is the major source of water for the San Joaquin River and the larger tributaries. Historically, peak flows occurred in May and June, and natural overbank flooding occurred in most years along all the major rivers. When flood flows reached the valley floor, they spread out over the lowland, creating several hundred thousand acres of permanent tule marshes and over 1.5 million acres of seasonally flooded wetlands and native grasslands. The rich alluvial soils of natural levees once supported large, diverse riparian forests. Above the lower floodplain, the riparian zone graded into higher floodplains, supporting valley oak savanna and native grasslands interspersed with vernal pools. Currently, about 126,000 acres of wetlands remain in the San Joaquin Valley. Riparian forest acreage is less than 5% of its former extent and exists in small, isolated patches. Human-made levees isolate the river from most of its former floodplain.

Riparian forest acreage is less than 5% of its former extent and exists in small, isolated patches. Human-made levees isolate the river from most of its former floodplain.

Most of the total volume of annual runoff in the San Joaquin River Region is stored in reservoirs; therefore, outflow from this region is highly regulated. Relative to natural flow conditions, the present flow of the San Joaquin River and its tributaries is lower year-round, especially in spring and winter. The reservoirs function as settling basins for all of the coarse sediment and organic material, and a large fraction of the fine sediments brought in each year by inlet streams.

The mainstream of the San Joaquin River during the summer growing season is composed of primarily agricultural return flow that is rich in nutrients and suspended solids. In winter, soils are flushed to reduce salt buildup, and the resulting wastewater is conveyed to the streams and San Joaquin River by an extensive system of tile lines and drainage ditches. High nutrient concentrations and long residence times combine to make the San Joaquin River mainstream an extremely productive system. Therefore, the San Joaquin River contributes a disproportionately high percentage of inflowing nutrients and food resources to the Delta. These nutrients and food resources contribute to Bay-Delta productivity but, in combination with sewage and urban discharge, may substantially alter foodweb dynamics and lead to reduced summer and fall dissolved oxygen levels in localized reaches of deep, poorly flushed channels.

High nutrient concentrations and long residence times combine to make the San Joaquin River mainstream an extremely productive system. Therefore, the San Joaquin River contributes a disproportionately high percentage of inflowing nutrients and food resources to the Delta.

On the west side of the region, over 100,000 acres of land are underlain by shallow, semi-impermeable clay layers that prevent water from percolating downward. Soils in this region are naturally high in selenium. Inadequate natural drainage, salt accumulation, and high selenium concentrations in agricultural return flow have been long-standing problems in this area and have intensified with the importation of irrigation water from the Delta. In addition to nutrients, the San Joaquin River is a major source of herbicide and pesticide loading to the Delta.

In addition to nutrients, the San Joaquin River is a major source of herbicide and pesticide loading to the Delta.

6.1.3.5 OTHER SWP AND CVP SERVICE AREAS

Two distinct, noncontiguous areas are included in the Other SWP and CVP Service Areas: in the north, are the San Felipe Division's CVP and the South Bay SWP service areas; to the south, are the SWP service areas. The northern section of this region encompasses parts of the central coast counties of Santa Clara, San Benito, Santa Cruz, and Monterey. The southern portion includes parts of Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Ventura Counties.

Reservoirs, streams, and estuaries in the Other SWP and CVP Service Areas receive water exported from the Delta. Much of the area receiving Central Valley water is highly urbanized, although extensive agricultural areas exist. The Los Angeles basin, formed by the Los Angeles, San Gabriel, and Santa Ana Rivers, has been the site of extensive urbanization. Streams in the region have been severely degraded by loss of streamflow to diversions and groundwater pumping; discharge of municipal, industrial, and agricultural waste; and channel modification, including dams, levees, and concrete channels to minimize flood damage.

Importation of water from the Central Valley has maintained or increased urban and agricultural development, further degrading aquatic systems through loss, disturbance, and contamination of species habitat. In addition, imported Central Valley water has introduced non-native species into and altered the foodweb dynamics of streams and estuaries.

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6.1.4 ASSESSMENT METHODS

The presentation of impacts is organized by region and subdivided into Program elements. The Program elements would affect physical, chemical, and biological features of the aquatic ecosystem. The effect of Program implementation on fish and aquatic resources are described using qualitative data, which include hypothetical relationships between potential Program actions and expected ecosystem or species response; measured data, such as changes in floodplain acreage or river length; and modeled data, such as simulated flow, reservoir storage, and diversion.

The effects of Program elements are considered at the ecosystem and species level. The ecosystem-level analysis focuses on the change in functional and structural characteristics of the aquatic ecosystem. Because species—especially those listed or proposed for listing under the ESAs—are key factors in conflicts over beneficial uses of water in the Delta-Bay ecosystem, effects of changes in environmental characteristics on species abundance and distribution also are assessed. Indicators of change in functional and structural characteristics are evaluated to determine the beneficial or adverse impacts of an action. The assessment relationships were selected based on:

- Sensitivity to change in environmental variables that enables at least a qualitative comparison of the alternatives at the programmatic level of analysis.

- Availability of supporting data, including current and historical data or professional judgement.

- Fair and consistent applicability to all alternatives.

Assessment of impacts requires application of explicit relationships. The relationships that follow are based on the best available information, but most of the relationships identified below have a high degree of uncertainty relative to action and response mechanisms. The uncertainty stems from natural variability in ecosystem function and structure, and from the absence or inaccuracy of information about ecosystem and species responses to particular variables. Resolution of the controversy resulting from uncertainty in the relationships was previously discussed (see Section 6.1.2, "Areas of Controversy").

Assessment of impacts requires application of explicit relationships. The relationships that follow are based on the best available information, but most of the relationships identified below have a high degree of uncertainty relative to action and response mechanisms.

Ecosystem-Level Analysis. Analysis at the ecosystem level addresses fundamental ecological processes and structure that help create and maintain biological communities and associated species habitat. Ecosystem processes act directly, indirectly, or in combination to shape, form, and maintain the Bay-Delta river system. Processes included in the programmatic impact assessment are flow; water temperature (heat transfer and storage); sediment, nutrient, and contaminant input and movement; and productivity. Ecosystem structure refers to physical components of the Bay-Delta river system and their spatial relationships to one another.

Flow. Flow affects a multitude of physical, chemical, and biological processes that operate in stream and estuarine channels, and flow is a primary driving force within the riverine ecosystem. The assessment relationship for flow assumes that reestablishing the basic hydrologic features reactivates and maintains ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Basic hydrologic features include:

- Flow variability that approximates the natural seasonal flow variability (that is, the pattern and magnitude), including effects of Delta outflow on natural seasonal variability in salinity distribution.

- Flow conditions in Delta channels, including net and tidal flow effects, that emulate natural channel flow conditions.

Changes in flow that approximate the natural seasonal pattern were assumed to restore flow-related processes in the aquatic ecosystem, including residence time, flow pattern, and transport rates. In Delta channels, flow pattern includes net flow direction and tidal flow. The natural net flow direction for Delta channels is toward Suisun Bay. Bi-directional tidal flow in the Bay-Delta is affected by change in structural characteristics. Tidal flow affects essential processes associated with mixing, cycling, and movement. Reestablishing historical tidal connections and restoring the natural structure of the Delta were assumed to restore essential processes associated with tidal flow.

Changes in flow that approximate the natural seasonal pattern were assumed to restore flow-related processes in the aquatic ecosystem, including residence time flow pattern, and transport rates.

The Bay-Delta ecosystems are characterized by short-term, seasonal, annual, and long-term variability in salinity. Natural variability in salinity distribution is important to maintaining a healthy estuarine ecosystem. Salinity influences a multitude of ecological processes, including those influencing the distribution and abundance of wetland vegetation and other aquatic organisms. Flow is the primary determinant of salinity distribution. Changes in Delta outflow that result in salinity distribution more closely approximating the natural seasonal pattern were assumed to restore salinity-related processes in the Delta and Bay ecosystems.

Water Temperature. Water temperature is primarily a function of heat transfer and storage. Water temperature affects a multitude of physical, chemical, and biological processes. Human-caused changes in the Bay-Delta river system have altered heat transfer and storage mechanisms, and have resulted in major changes in short-term and seasonal water temperature variability. The assessment relationship for water temperature assumes that reestablishing basic heat transfer and storage mechanisms reactivates and maintains ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Actions that may restore basic heat transfer and storage mechanisms include:

The assessment relationship for water temperature assumes that reestablishing basic heat transfer and storage mechanisms reactivates and maintains ecological processes and structures that sustain healthy fish, wildlife, and plant populations.

- Reduction or relocation of agricultural return flows.

- Reduction or relocation of municipal and industrial discharges of thermal waste.

- Reestablishment of natural channel structure.

- Reestablishment of basic hydrologic features consistent with water temperature conditions required to maintain desired biological communities.

- Restored riparian vegetation and shaded riverine aquatic cover.

- Improved watershed management.

Reduced return flows and reduced discharge of heated municipal and industrial effluent may reduce thermal inputs to natural channels. Restoration of riparian vegetation, shaded riverine aquatic cover, and channel structure will provide shading and reestablish natural heating and cooling processes.

Although reestablishing natural channel structure and basic hydrologic features would facilitate natural heat transfer and storage, existing and future social and economic needs may prohibit such actions. For example, reservoirs substantially alter heat transfer and storage in rivers, but removal of dams may be infeasible given the ongoing needs of society. Therefore, the needs of desired biological communities (for example, cool-water biological communities that support chinook salmon and steelhead) must be considered in determining reservoir operations criteria. The detail required to determine the effects of reservoir operations on water temperature exceeds the detail of the hydrology simulated for this programmatic impact assessment; therefore, water temperature in river channels potentially affected by reservoir operations was not simulated, and assessment will be necessary in project-specific environmental documentation. Program actions could increase the availability of cool-water releases from reservoirs, however, and potentially maintain water temperatures that meet the needs of desired biological communities. Actions that could increase the availability of cool water include:

Although reestablishing natural channel structure and basic hydrologic features would facilitate natural heat transfer and storage, existing and future social and economic needs may prohibit such actions.

- Construction of multi-level reservoir release structures.

- Increased carry-over reservoir storage.

- Increased volume of water dedicated for ecological flow and water temperature purposes.

Multi-level release structures improve management of the cold-water pool, allowing release of warmer water during periods of low species sensitivity or low ambient air temperature. The cold-water pool in the reservoir is conserved for use during periods of greater species sensitivity and months when river water temperatures may exceed species needs. Similarly, increased carry-over storage and increased volume of water dedicated to flow and water temperature needs may increase the cold-water pool or increase the ability to affect downstream reaches, providing water temperature within target ranges. The actions identified above are applicable to river reaches below reservoirs and would minimally affect Delta water temperature. Because of the distance from the upstream reservoirs, water temperature in the Delta is primarily driven by weather.

Sediment and Nutrient Input and Movement. Input and movement of sediment and associated nutrients are important processes affecting the development and maintenance of the Bay-Delta river system. The assessment relationship for sediment and nutrient input and movement assumes that reestablishing natural sediment and nutrient delivery and movement within the system reactivates and maintains ecological processes and structures

The assessment relationship for sediment and nutrient input and movement assumes that re-establishing natural sediment and nutrient delivery and movement within the system reactivates and maintains ecological processes and structures that sustain healthy fish, wildlife, and plant populations.

that sustain healthy fish, wildlife, and plant populations. Basic sediment and nutrient delivery and movement mechanisms are reestablished by:

- Removal of dams and other barriers to sediment and nutrient movement.
- Cessation of or reduction in sediment extraction, such as gravel mining and dredging.
- Reestablishment of natural channel structure.
- Reestablishment of basic hydrologic features consistent with sediment movement dynamics required to maintain desired biological communities.
- Improved watershed management.
- Restoration of riparian, shaded riverine aquatic cover, marsh, and floodplain communities.
- Implementation of BMPs during construction activities.

Several of the actions reestablish pathways for sediment movement. Dams retain sediment, preventing movement from the upper watershed to downstream reaches. Removal of dams would reconnect the supply of sediment to downstream reaches of rivers and the estuary. Limits on sediment extraction also would maintain the supply of sediment to downstream reaches. Reestablishment of natural channel structure, including floodplain connections and river meanders, restores processes affecting movement of sediment within the main channel and from adjacent lands. Reestablishment of natural channel structure may include removal of levees, weirs, and bank protection.

Several of the actions reestablish pathways for sediment movement.

Watershed actions in both the upper and lower watersheds may address grazing, wildfires, agriculture, and urban development. Improved watershed management and restoration of riparian vegetation, shaded riverine aquatic cover, marsh, and floodplain communities would affect erosion and deposition processes, increasing sediment stability and restoring channel dynamics. Implementation of BMPs during construction activities would prevent short-term increases in sediment input that may adversely affect aquatic communities through increased sedimentation or turbidity.

Reservoirs capture sediment destined for downstream reaches, and flood control elements of the Bay-Delta river system, such as levees, have resulted in major changes to channel structure. Although reestablishment of natural flow patterns potentially restores natural sediment input and movement processes, natural flows through the existing system could mobilize previously stable sediments and damage existing or desired biodiversity and the integrity of the aquatic ecosystem. Biological communities and species with specific sediment requirements (for example, spawning gravels for chinook salmon and steelhead) could be adversely affected. Reestablishment of natural flow patterns requires consideration of management priorities and concurrent actions to reestablish natural channel structure and restore riparian, floodplain, wetland, and aquatic communities.

Reservoirs capture sediment destined for downstream reaches, and flood control elements of the Bay-Delta river system, such as levees, have resulted in major changes to channel structure.

Because dams, gravel mining, and subsequent flow conditions have reduced sediment abundance in some river reaches, adding sediment replaces, to some degree, the natural process of gravel recruitment now interrupted by dams. Although adding gravel to river channels is inconsistent with reestablishing natural sediment and nutrient delivery and movement, the action may be necessary to maintain and enhance desired biological communities and species populations.

Contaminant Input and Movement. Contaminants are substances that are toxic to aquatic organisms or create conditions that adversely affect aquatic organisms in the Bay-Delta river system. Contaminants include metals (for example, mercury, copper, cadmium, and zinc), selenium, ammonia, salinity from runoff, pesticides, fertilizers, sewage, uncharacteristically high fine sediment loading, and warmwater. Toxic effects of contaminants may include death, reduced growth rate, and reduced fertility of individual organisms. Reduced dissolved oxygen levels, in response to input of excessive nutrients from agricultural and urban runoff , sewage, or warmwater discharge, also may adversely affect aquatic organisms.

The assessment relationship for contaminant input and movement assumes that reducing contaminant delivery and movement within the system reactivates and maintains ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Reduced contaminant input and movement may be achieved through:

> The assessment relationship for contaminant input and movement assumes that reducing contaminant delivery and movement within the system reactivates and maintains ecological processes and structures that sustain healthy fish, wildlife, and plant populations.

- Development of more benign application techniques, development of narrow-spectrum pest control methods, and use of shorter-lived or less mobile agricultural and industrial chemicals.

- Improved point and nonpoint wastewater treatment prior to discharge.

- Improved watershed management.

- Implementation of BMPs during construction activities.

Improved point and nonpoint wastewater treatment may include upgraded sewage treatment, construction of stormwater runoff storage, and discharge to constructed wetlands prior to discharge to the Bay-Delta river system. Watershed management could reduce excessive input of fine sediment, pesticides, and other material. Watershed actions in both the upper and lower watersheds may address grazing, wildfires, agriculture, and urban development. Implementation of BMPs during construction activities would prevent short-term discharge of contaminants and reduce the probability of contaminant spills.

In addition to reduced inputs, natural biological processing of contaminants may be increased by restoring marshes and wetlands. Reliance on natural processing of contaminants, however, must include implementation of monitoring and mitigation components. Monitoring should focus on detecting increased contaminant concentrations and the potential for aquatic organisms to accumulate, magnify, transform, and mobilize contaminants to the detriment of aquatic communities or individual organisms. The mitigation should include potential actions to reduce or eliminate input of contaminants and remove contaminants accumulated in sediment or vegetation.

Although reduced contaminant input is the primary avenue for reactivating and maintaining ecological processes and structures that sustain healthy fish, wildlife, and plant populations, reduced contaminant effects also may be achieved through avoidance mechanisms, including:

Although reduced contaminant input is the primary avenue for reactivating and maintaining ecological processes and structures that sustain healthy fish, wildlife, and plant populations, reduced contaminant effects also may be achieved through avoidance mechanisms.

- Discharge of contaminants during nonsensitive periods
- Relocation of discharges to less sensitive areas
- Discharge during periods of high dilution

Contaminants may be discharged when biological communities are less sensitive or when sensitive life stages are not present. Relocating the discharge to areas not supporting sensitive species also would minimize adverse affects. Channel flow may reduce the concentration of contaminants (such as salts from agricultural return flow to the San Joaquin River); increased flow may be achieved by increasing reservoir releases, reducing diversion, or operating barriers to direct flow along pathways receiving contaminants. The need for dilution flows needs may not coincide with other flow needs associated with reactivation and maintenance of ecological processes and structure, and may have limited ecosystem benefits because contaminants continue to enter the ecosystem.

Productivity. Productivity is the capacity of the aquatic ecosystem to produce a product of interest (for example, a species population or group of species). The capacity of an ecosystem to produce a product of interest depends on basic energy and material resources, both those developed within an ecosystem and those introduced from external sources. Changes in energy and material resources inevitably lead to changes in the abundance of species and in ecological communities. Healthy fish, wildlife, and plant populations in the Bay-Delta river system depend on the maintenance and improvement of processes that affect productivity.

Through density-dependent relations, an increase or decrease in the basic energy and material resources changes the abundance of food, affects the abundance of species, and changes production-biomass relationships. Even small changes in basic energy and material resources (for example, input of organic material) may cause substantial changes in the capacity of the Bay-Delta river ecosystem to produce organisms, altering aquatic communities and affecting species abundance.

The complexity and magnitude of energy and material transfer through the ecosystem have limited the understanding of cause-and-effect productivity relationships to relatively simple controlled studies. Pathways of energy and material transfer through the Bay-Delta river ecosystem eventually may be described in qualitative terms; but quantifying rates of food consumption, assimilation, respiration, growth, and production through all trophic pathways in the ecosystem is not possible. Although results will be speculative, impacts of project actions on productivity of the Bay-Delta river system warrants consideration because human activities substantially affect production, including changes in species abundance.

The complexity and magnitude of energy and material transfer through the ecosystem have limited the understanding of cause-and-effect productivity relationships to relatively simple controlled studies.

The assessment relationship for productivity assumes that reestablishing natural conditions of energy and material transfer through the ecosystem reactivates and maintains ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Basic energy and material transfer mechanisms are reestablished by:

- Reducing the loss of nutrients and organisms to diversions.
- Reducing input of contaminants.
- Reestablishing basic hydrologic features, including flow variability and residence time.
- Reestablishing conditions that approximate the natural sediment and nutrient delivery to the system.
- Restoring structural characteristics to approximate the natural structural characteristics of the aquatic ecosystem.

The assessment relationship for productivity assumes that reestablishing natural conditions of energy and material transfer through the ecosystem reactivates and maintains ecological processes and structures that sustain healthy fish, wildlife, and plant populations.

Diversions remove material from the ecosystem, affecting the capacity of the ecosystem to produce products of interest through direct reduction of both food and species abundance. Adverse impacts of diversions on productivity may be lessened through reduced diversion volume, relocation of diversions outside the range for species of interest (although relatively large diversions may continue to affect downstream productivity though removal of nutrients and organisms), reoperation of diversions to avoid sensitive periods (for example, during periods of high biomass or susceptible life stages), and installation of fish protection facilities (for example, fish screens).

Adverse impacts of diversions on productivity may be lessened through reduced diversion volume, relocation of diversions outside the range for species of interest, reoperation of diversions to avoid sensitive periods, and installation of fish protection facilities.

Input of contaminants may increase mortality or decrease reproduction and growth, reducing food and species abundance. Actions that reduce contaminant input are discussed under "Contaminant Input and Movement."

Reestablishing basic flow and structural features, in combination with reestablishing natural sediment and nutrient delivery, moves the system toward natural ecosystem conditions. Restoring marshes and riparian forests would increase primary production by emergent vascular plants, and greater open water area could increase phytoplankton production. Restoration of upstream floodplain connections would reestablish delivery of organisms, detritus, and dissolved organic material to the Delta. Increased productivity for products of interest, however, is speculative because of the complexity and magnitude of energy and material transfer through the ecosystem; and because historical changes, including introduced species, continue to affect future productivity. Exotic species such as Asian clams may impede reestablishing any semblance to natural energy and material transfer.

Structure. Ecosystem structure refers to physical components of the Bay-Delta river system and their spatial relationships to one another. Structure substantially affects processes discussed above, including flow, water temperature, sediment and nutrient input and movement, contaminant input and movement, and productivity. The assessment relationship for structure assumes that reestablishing the natural structural features reactivates

The assessment relationship for structure assumes that reestablishing the natural structural features reactivates and maintains ecological processes and structures that sustain healthy fish, wildlife, and plant populations.

and maintains ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Reestablishment of natural structure may include:

- Restoration of area, volume, and length of major surface and subsurface features of the aquatic ecosystem.
- Removal of channel constraints.
- Reestablishment of riparian, marsh, and wetland plant communities.

Major surface and subsurface features of the aquatic ecosystem include floodplain, flooded islands, dead-end sloughs, tidal and river channels, riparian communities, and tidal marsh. Delta island levees may be breached to create additional aquatic habitat. Dams and barriers may be removed to reconnect aquatic habitats to the existing aquatic ecosystem. The floodplain may be reconnected to the river through breached or setback levees, or reconfiguration of floodplain elevation—increasing the frequency, duration, and area of flooded habitat. Removal of channel constraints may include removal of bank revetment, setback levees, and suspension of dredging activities. Removal of channel constraints, in addition to reconnecting the floodplain to the aquatic ecosystem and increasing aquatic area, would allow reestablishment of channel density and complexity—increasing species habitat diversity. Allowing and encouraging reestablishment of riparian, marsh, and wetland vegetation through planting and revision of vegetation control programs would add structure to the aquatic ecosystem; provide cover for species; contribute to processes that increase channel density and complexity; and subsequently create additional ecosystem area, volume, and length.

Species-Specific Analysis. This section describes the method for assessing the effects of Program actions on species. All aquatic species in the Bay-Delta system possess an intrinsic value as components of biological diversity. Several species in the system also have significant social and political value, including value to commercial and sport fisheries.

All aquatic species in the Bay-Delta system possess an intrinsic value as components of biological diversity. Several species in the system also have significant social and political value, including value to commercial and sport fisheries.

The factors that limit abundance and production are generally not known, which is an inherent problem in species analysis. Without knowing limiting factors, cause-and-effect relationships are speculative, and predicted effects or responses to specific actions are uncertain (see Section 6.1.2, "Areas of Controversy"). A qualitative analysis at the species-specific level is based on factors that may affect abundance and distribution of selected aquatic species, primarily species listed or proposed for listing under federal and California ESAs (winter-, spring-, fall-, and late fall-run chinook salmon; steelhead; delta smelt; and splittail). Assessment relationships are grouped into eight categories: habitat, water quality, entrainment, water surface level, movement, species interactions, artificial production, and harvest. Species and life-stage needs, along with geographical and seasonal occurrence, determine application of the species-specific relationships identified below.

Physical Habitat Relationships. Physical habitat includes the resources and conditions present in an area that allow an organism to survive, grow, and reproduce. These factors include spawning areas, rearing areas, and migration pathways. In the project area, habitat loss and degraded value have substantially contributed to the decline of many species. Providing habitat is critical to maintaining and increasing the abundance and distribution of all representative species.

Physical habitat relationships focus primarily on habitat abundance. "Habitat abundance" refers to the abundance of specific resources that are used by an organism. For example, increased area of spawning gravel increases the spawning habitat abundance for chinook salmon. Although density-dependent factors partially determine whether habitat is limiting the abundance and distribution of a species, the assessment relationship for habitat assumes that increased habitat abundance benefits a species (that is, increased habitat improves survival, growth, and reproductive success; and ultimately increases abundance and distribution). Depending on the species, habitat abundance may increase when:

Physical habitat relationships focus primarily on habitat abundance. "Habitat abundance" refers to the abundance of specific resources that are used by an organism.

- Levees and hard bank protection (for example, rip-rap) in the Delta and along rivers are breached, set back, removed, or alternatively managed for biological benefits.
- Barriers to movement of organisms are removed from river or Delta channels.
- Flow, water temperature, and salinity are modified to provide for specific species needs.
- Riparian, wetland, and marsh areas are restored and reconnected to the Delta or riverine aquatic ecosystem.
- Natural or artificial sediment input and movement is reestablished (for example, removal of dams or addition of gravel to selected stream reaches).

An increase in the area, volume, and length of habitat (from breach, setback, or removal of levees in the Delta and along rivers) and an increase in the length of river or Delta channels not blocked by dams and other barriers was assumed to provide additional habitat for the representative species. The extent of benefits to individual species will depend on the location and type of restoration relative to the spawning and rearing habitat needs of each species.

An increase in the area, volume, and length of habitat (from breach, set-back, or removal of levees in the Delta and along rivers) and an increase in the length of river or Delta channels not blocked by dams and other barriers was assumed to provide additional habitat for the representative species.

Improved habitat conditions attributable to flow, water temperature, and salinity changes that provide for specific species needs were assumed to increase habitat abundance. As mentioned previously, species needs relative to factors limiting abundance are speculative, and the assessment is based on a general understanding of expected species response to ecosystem processes, not on a clear understanding of specific mechanisms. For example, abundance of many species is higher under high Delta outflow conditions. High abundance may be attributable to many mechanisms, including increased habitat abundance and other mechanisms discussed below (for example, entrainment and movement).

Flow and water temperature needs of some species may be inconsistent with natural conditions. For example, reservoirs have blocked access to most of the historical habitat used by chinook salmon and steelhead, and existing populations are restricted to habitat downstream of the major reservoirs. Under natural conditions, the river reaches below reservoirs may have provided marginal water temperature and flow conditions that were insufficient to sustain viable chinook salmon and steelhead populations. Therefore, the target range for flow and water temperature management with reservoir operations must reflect the needs of desired species.

Increased habitat abundance was assumed to benefit species of interest, but habitat created near major diversions may be of minimal benefit because individuals or food organisms may be lost to entrainment. In addition, restoration may not increase habitat abundance because the restored or reclaimed areas are isolated from existing species populations or do not provide environmental conditions that are consistent with a species needs (for example, depth, velocity, salinity, substrate, and cover). Introduced species further complicate the response of native species populations to increased habitat abundance because introduced species populations may increase, subsequently increasing competition and predation on native species (for example, interactions between introduced silversides and native delta smelt or the effects of introduced Asian clams on primary productivity).

Increased habitat abundance was assumed to benefit species of interest, but habitat created near major diversions may be of minimal benefit because individuals or food organisms may be lost to entrainment.

Water Quality Relationships. Death, reduced growth, or reduced reproductive success occur when water quality stresses the metabolic tolerances of an organism. The detail provided by information developed for this programmatic EIS/EIR is insufficient for species-level assessment of water quality impacts. Impacts identified at the ecosystem-level assessment for contaminants were assumed to reflect impact direction for species that occur in the affected areas.

Entrainment Relationships. Water diversions cause fish mortality through entrainment (and subsequent movement to inappropriate habitat), impingement on fish screens or other diversion structures, abrasion, stress as a result of handling, and increased predation. Entrainment and associated mortality is a concern for all fish species included in the impact assessment. Life stages most vulnerable to entrainment vary by species. For example, chinook salmon and steelhead are most affected during fry and juvenile rearing and downstream migration. Some species, such as striped bass and American shad, are most vulnerable during the egg and larval stages, although they are also vulnerable to entrainment as juveniles. Delta smelt are vulnerable as larvae, juveniles, and adults because of their small size at maturity and year-round residence near diversions. Adults of the large-bodied species, such as striped bass, chinook salmon, green and white sturgeon, and American shad, are minimally affected by diversion operations and facilities.

The assessment relationship for entrainment assumes that reduced entrainment-related losses will increase species abundance and distribution. Entrainment-related losses may be reduced by:

- Construction of new or improved fish screens.
- Relocation of diversions to areas outside the distribution of a species.

The assessment relationship for entrainment assumes that reduced entrainment-related losses will increase species abundance and distribution.

- Redistribution of species populations to Suisun Bay, subsequently reducing exposure to Delta diversions.
- Reoperation of diversions to avoid periods when species are present.
- Redesign of diversions and associated facilities to reduce predator habitat or control predators in diversion facility components (that is, screen bays).

Program actions to construct and improve fish screens would reduce the loss of life stages large enough to be efficiently screened; however, fish screens would provide minimal protection for planktonic eggs and larvae. American shad and striped bass spawn planktonic eggs that are small and pass through the fish screens. The planktonic larvae of American shad, striped bass, delta smelt, and longfin smelt would either pass through the screens or, because larvae are weak swimmers, be impinged on the screen surface.

Program actions to construct and improve fish screens would reduce the loss of life stages large enough to be efficiently screened; however, fish screens would provide minimal protection for planktonic eggs and larvae.

Diversion facilities provide habitat and increased feeding opportunity for predatory fish. Predation on desired species may be reduced by control of predators within facility components or a change in facility design to reduce predator habitat and prey vulnerability.

A shift in estuarine salinity may alter the geographic distribution of aquatic organisms. The occurrence of the 2-parts per thousand (ppt) salinity zone upstream of Chipps Island shifts the primary distribution of larval and juvenile delta smelt and striped bass into the Delta. Redistributing species to Suisun Bay, through provision of conditions meeting species needs (for example, salinity), reduces exposure to Delta diversions and potentially reduces diversion-related mortality.

Water Surface-Level Relationships. Short-term changes in water surface levels may result in mortality by exposing nests, stranding individuals, reducing or eliminating cover, and other means. Chinook salmon, steelhead, largemouth bass, and splittail are representative of species sensitive to water surface-level fluctuation in rivers; largemouth bass are representative of species sensitive to reservoir fluctuations. Chinook salmon and steelhead lay eggs in gravel nests, splittail lay eggs on flooded vegetation, and largemouth bass lay eggs in nests in relatively shallow water near the reservoir shore. Increased frequency and magnitude of short-term water surface-level fluctuation increases mortality caused by exposure of nests; desiccation of eggs; and mortality associated with movement of larvae and juveniles into less optimal habitat, where food may be less available and vulnerability to predation may increase.

The assessment relationship for water surface-level assumes that reduced human-caused fluctuation will reduce losses and increase species abundance and distribution. Information developed for this programmatic EIS/EIR is generally insufficient for species-level assessment of water surface-level changes; however, effects of Program actions that reduce human-induced water surface-level fluctuations are considered qualitatively. Human-caused water surface-level fluctuations may be reduced by:

The assessment relationship for water surface-level assumes that reduced human-caused fluctuation will reduce losses and increase species abundance and distribution.

- Management of reservoir operations to minimize short-term flow fluctuation in rivers.

- Management of reservoirs to minimize drawdown during spawning and early rearing periods.

- Construction of Program elements that minimize human-caused isolation of aquatic ecosystem components.

Program actions that minimize flow reduction in rivers over short time intervals were assumed to improve habitat conditions affected by water surface-level fluctuation and benefit affected species. For reservoirs, Program actions that minimize drawdown during spring and summer were assumed to reduce mortality attributable to short-term water surface-level fluctuation and benefit reservoir species.

Program elements that minimize human-caused isolation of aquatic ecosystem components include filling gravel mining pits; establishing permanent or seasonal connections between oxbows and sloughs and the main river channel; and recontouring the flood bypasses, including isolated ponds, agricultural fields, and sloughs, to establish efficient connections to main drainage channels. Seasonal connections must coincide with species needs relative to use of spawning and rearing habitat.

Movement Relationships. Movement of organisms includes passive transport, migration, and attraction. Passive transport is the movement of organisms with flow. In rivers, passive transport is downstream. In the Delta and Bay, passive transport with tidal currents is bi-directional. Planktonic or free-drifting organisms, including planktonic fish eggs and larvae, depend on passive transport to reach rearing habitat, although some planktonic organisms may vertically migrate to slow or accelerate movement in a specific direction. American shad, striped bass, delta smelt, longfin smelt, and splittail have planktonic egg or larval life stages dependent on passive transport.

Migration entails active movement of organisms either with or against flow; attraction is active movement in response to flow or water quality stimuli. Many adult and juvenile fish, including chinook salmon, American shad, splittail, steelhead, longfin smelt, and delta smelt, migrate in response to seasonal spawning and rearing habitat needs. Flow and water quality may stimulate and guide seasonal migration.

The assessment relationship for movement assumes that improved transport, migration, and attraction conditions will improve growth, survival, and reproduction, as well as increase species abundance and distribution. Transport, migration, and attraction conditions may be improved by:

- Reestablishing natural hydrologic features.

- Establishing appropriate seasonal water temperature conditions in managed reaches that are consistent with the needs of desired species.

The assessment relationship for movement assumes that improved transport, migration, and attraction conditions will improve growth, survival, and reproduction, as well as increase species abundance and distribution.

- Restoring natural water quality conditions, including sediment, nutrient, and contaminant input and movement.

- Reestablishing ecosystem connectivity.

Improvement in transport, migration, and attraction conditions attributable to reestablishing natural hydrologic features that provide for specific species needs (for example, flow, water temperature, and salinity) was assumed to improve growth, survival, and reproduction. As mentioned previously, species needs relative to factors limiting abundance are speculative; assessment is based on a general understanding of expected species response to ecosystem processes, not on a clear understanding of specific mechanisms. For example, abundance of many species is higher under high Delta outflow conditions. High abundance may be attributable to many mechanisms, including increased habitat abundance, increased prey availability, improved access to spawning and rearing habitat, improved migratory cues, and transport away from diversions.

Flow that emulates natural patterns was assumed to improve survival during downstream movement of juvenile chinook salmon and steelhead; striped bass eggs and larvae; sturgeon larvae and juveniles; and American shad eggs, larvae, and juveniles. In addition, natural flow patterns are assumed to ensure necessary attraction cues for adult chinook salmon, steelhead, delta smelt, splittail, and other species. Project actions that provide flow events consistent with natural flow patterns and consistent with species needs were assumed to move juvenile fish into suitable rearing areas, provide cues that reduce outmigration delay, provide attraction for upstream migration of adults, and increase survival.

Flow that emulates natural patterns was assumed to improve survival during downstream movement of juvenile chinook salmon and steelhead; striped bass eggs and larvae; sturgeon larvae and juveniles; and American shad eggs, larvae, and juveniles.

In the Delta, natural net channel conditions (for example, flow toward Suisun Bay) were assumed to facilitate movement of organisms to downstream habitat more conducive to increased growth and survival. For chinook salmon of both Sacramento River and San Joaquin River origin, mortality during migration through the Delta may vary depending on pathway and environmental conditions, such as water temperature and dissolved oxygen levels. Under existing conditions, the mortality of juvenile chinook salmon that move into the DCC and Georgiana Slough from the Sacramento River is greater than the mortality of juvenile chinook salmon that continue down the Sacramento River toward Rio Vista. Steelhead were assumed to be affected similarly.

In the Delta, natural net channel conditions (for example, flow toward Suisun Bay) were assumed to facilitate movement of organisms to downstream habitat more conducive to increased growth and survival.

For San Joaquin River chinook salmon, juveniles that move with flow into Old River at Mossdale may suffer greater mortality than juvenile chinook salmon that continue down the San Joaquin River toward Stockton. Additionally, increased net flow toward the south in Old and Middle Rivers and connected channels may increase entrainment of chinook salmon, steelhead, delta smelt, striped bass, and other species in the south Delta diversions.

Ecosystem connectivity may be reestablished through removal and modification of barriers, installation and improvement to fish passage facilities, and restoration of channel structure to facilitate access to resources and conditions that allow a species to survive and reproduce.

Relationships discussed above are controversial because of uncertainty arising from incomplete knowledge of species needs and unpredictable responses to environmental changes. Implementation of actions that support movement will depend on developing knowledge of species needs and understanding effects of Program elements (see Section 6.1.2, "Areas of Controversy").

Species Interactions. Predation occurs naturally in the system; however, fish and other aquatic organisms that are stressed by toxicants, elevated water temperatures, turbulence created by barriers or screening facilities, and other factors may be more susceptible to predation and experience artificially high mortality rates. Artificial structures can create predatory fish holding areas and ambush sites. Artificial structures that block and delay fish passage may increase predation opportunities. In-channel gravel mining and other activities affecting channel structure has created predator habitat and increased vulnerability of desired species to predation.

The assessment relationship for species interactions assumes that maintenance of native species communities will improve survival and increase the abundance and distribution of desired species. Native species assemblages of aquatic organisms have been irreversibly altered, especially in the Delta where introduced species dominate the existing fish fauna. Eradication of introduced aquatic species is currently infeasible; however, native species communities would benefit from programs that reduce or eliminate the influx of non-native aquatic species in ship ballast water and reduce the potential for influx of non-native aquatic plant and animal species at border crossings. Controlling the introduction of non-native species potentially halts continued escalation of unnatural levels of competition, predation, and disease.

The assessment relationship for species interactions assumes that maintenance of native species communities will improve survival and increase the abundance and distribution of desired species.

Maintaining and restoring natural habitats, including a return to hydrologic, temperature, and structural conditions that favor native species, also would benefit native species communities. Where societal goals limit restoration, programs that control predator populations or reduce habitat for predators may be implemented to increase the survival of desired species.

Artificial Production. Supplementation of natural populations may be necessary if (1) natural populations are declining, (2) habitat is available but under-utilized, (3) future losses to the population cannot be averted through restoration actions in the near term, and (4) artificial production technologies exist that enable enhancement of natural populations. Artificial production that increases the fitness of natural spawning and rearing populations will increase the abundance and distribution of desired species. Fitness of natural spawning and rearing populations may be maintained through:

- Careful selection of wild populations to be supplemented.
- Limiting the amount of artificial production added to a natural population based on numbers needed to maintain population integrity.
- Use of only wild fish as broodstock. Marking of all artificially produced fish is an integral part of wild fish identification.

- Consideration of stocking location and timing relative to natural fish population sensitivity.

- Modification of artificial rearing environments to be more similar to natural environments and to reduce differential reproductive success.

- Consideration of genetic effects in benefit-cost determinations for the need of artificial supplementation.

Artificial production of salmon and steelhead can increase predation and competition with naturally produced populations, lower the genetic integrity of natural populations, and increase harvest rates on natural populations. The beneficial impacts of artificial production for natural populations are uncertain, and only avoidance or minimization of supplementation will clearly avoid adverse effects on desired species populations.

The beneficial impacts of artificial production for natural populations are uncertain, and only avoidance or minimization of supplementation will clearly avoid adverse effects on desired species populations.

Harvest. Harvest management recommendations would be designed in a manner consistent with the Program solution principle of "no significant redirected impacts" on fishing interests. Illegal and legal harvest of fish can adversely affect the abundance of desired natural populations, such as chinook salmon, steelhead, striped bass, and other sport and commercially valuable species. Harvest that is consistent with maintaining the fitness of natural spawning and rearing populations will avoid adverse effects on the abundance and distribution of desired species populations. Fitness of natural spawning and rearing populations may be maintained through:

Harvest that is consistent with maintaining the fitness of natural spawning and rearing populations will avoid adverse effects on the abundance and distribution of desired species populations.

- Increased law enforcement and implementation of programs to increase public awareness and reporting of illegal harvest violations.

- Limiting the harvest of natural populations based on numbers needed to maintain population integrity, including allowances for variable environmental conditions that affect productivity.

- Clear separation of harvest goals for artificially and naturally produced fish, possibly requiring marking of all artificially produced fish.

6.1.5 SIGNIFICANCE CRITERIA

The general nature of the planning and the broad range of settings and impacts contained in the Revised Phase II Report dictate the use of qualitative thresholds of significance for the Programmatic EIS/EIR. Thresholds are phrased in qualitative terms, indicating potential changes from either existing conditions or conditions under the No Action Alternative.

Program actions are considered beneficial if the changes in structural and functional characteristics may result in an ecosystem that emulates a natural, functioning, self-regulating system that is integrated with the ecological landscape in which it occurs.

Program actions are considered beneficial if the changes in structural and functional characteristics may result in an ecosystem that emulates a natural, functioning, self-regulating system that is integrated with the ecological landscape in which it occurs. In addition, actions are considered beneficial if changes in environmental conditions are likely to halt or reverse downward trends in native species abundance and distribution relative to existing conditions.

Adverse impacts are considered potentially significant when Program actions cause or contribute to substantial short- or long-term reductions in aquatic ecosystem characteristics, and degrade conditions that potentially reduce abundance and distribution of species populations. An adverse effect is considered potentially significant if it substantially degrades aquatic ecosystem processes; substantially reduces the structural characteristics of the aquatic ecosystem; or substantially degrades the conditions affecting or potentially affecting the abundance or range of a species with economic or social value; harms a rare, threatened, and endangered species or its habitat; or has considerable effects when viewed with past, current, and reasonably foreseeable future projects.

6.1.6 NO ACTION ALTERNATIVE

Existing conditions are the environmental baseline against which the expected ecosystem and species response to future actions are compared. Given the programmatic level of analysis, what we know of existing conditions, and what we can predict to 2020, the discussion of differences between the No Action Alternative and existing conditions focus primarily on changes in water project operations, new or modified facilities, and projected increase in water demands that are not associated with the Program.

6.1.6.1 DELTA REGION

Although simulated SWP and CVP annual deliveries would increase by about 7% relative to existing conditions, monthly Delta inflow and outflow would be similar under the No Action Alternative and existing conditions. Operations rules and hydrologic variation would limit the ability to alter flow patterns and the associated salinity distribution in the Delta. Possible ESA protection criteria could reduce annual SWP and CVP south-of-Delta deliveries relative to existing conditions. The change in Delta flow patterns could move slightly toward natural patterns, potentially benefitting Delta species.

Projects identified as part of the No Action Alternative would cause minimal effects on water temperature, sediment input and movement, and ecosystem structure relative to existing conditions. Actions upstream of the Delta, such as the Sacramento River Flood Control Project (SRFCP), may slightly alter sediment supply and movement; but the small effects cannot be determined at the programmatic level and would need to be determined for specific projects.

Contaminant input under the 2020 level of development may increase. Increased input of urban and industrial contaminants would increase stress on biological processes (for

Contaminant input under the 2020 level of development may increase. Increased input of urban and industrial contaminants would increase stress on biological processes (for example, reduced organism growth and fecundity, and increased organism susceptibility to disease) and would adversely affect species population distribution and abundance.

example, reduced organism growth and fecundity, and increased organism susceptibility to disease) and would adversely affect species population distribution and abundance.

Relative to existing conditions, projects under the No Action Alternative that could increase biological productivity and nutrient input and movement in the aquatic ecosystem include changes in wildlife refuge operations and restoration associated with the Stone Lakes National Wildlife Refuge (NWR) and the SRFCP.

Structural characteristics of the Delta also would be similar for both the No Action Alternative and existing conditions. A project that may affect structural characteristics in a small part of the Delta ecosystem is the Stone Lakes NWR. Change in structural characteristics is considered a beneficial impact when the change moves toward a natural condition. Restoration of tidal marsh and connecting sloughs in the Stone Lakes NWR would result in small beneficial effects relative to the existing Delta aquatic system. The structural changes could result in a slight increase in spawning and rearing habitat for Delta species, including chinook salmon, Sacramento blackfish, Sacramento splittail, largemouth bass, and striped bass.

Structural characteristics of the Delta also would be similar for both the No Action Alternative and existing conditions.

6.1.6.2 BAY REGION

Under the No Action Alternative, effects on fisheries and aquatic ecosystems in the Bay Region primarily depend on movement of contaminants, sediment, nutrients, and production from the Delta Region. Change in simulated Delta outflow would be small and produce little effect on the Bay Region ecosystem, including the Suisun Marsh.

6.1.6.3 SACRAMENTO RIVER REGION

Although operations and surface water and groundwater storage would change under the No Action Alternative, Sacramento River and tributary flows would be similar to flows under existing conditions. Operations rules and demands, similar under both the No Action Alternative and existing conditions, would limit the ability to change flow patterns. Yuba River flows may be altered in response to revised regulations that will improve spawning and rearing conditions, providing a beneficial impact primarily on chinook salmon and steelhead.

Based on the relatively small change in flow and reservoir operations, water temperature conditions in most rivers in the Sacramento River Region under the No Action Alternative would be similar to temperature conditions under existing conditions. However, projects assumed under the No Action Alternative that could affect water temperature include the Shasta Temperature Control Device and interim reoperation of Folsom Reservoir. The additional flexibility for water temperature control from operation of the Shasta Temperature Control Device would benefit all runs of chinook salmon and steelhead trout that spawn and rear in the Sacramento River below Keswick Reservoir. In the American River, steelhead and chinook salmon currently are restricted

Based on the relatively small change in flow and reservoir operations, water temperature conditions in most rivers in the Sacramento River Region under the No Action Alternative would be similar to temperature conditions under existing conditions.

to habitat below Nimbus Dam. Reoperation of Folsom Reservoir may reduce summer flows and the availability of cool water released to the American River. Water temperature may increase, adversely affecting rearing and spawning conditions.

The SRFCP may affect structural characteristics of the Sacramento and American Rivers. Change in levee maintenance practices to allow development of natural riparian and shaded riverine aquatic communities would produce small beneficial effects relative to the existing levee system. The structural changes could result in a slight increase in rearing habitat for river species, including chinook salmon, steelhead trout, and Sacramento splittail.

6.1.6.4 San Joaquin River Region

As for the Sacramento River, differences between the No Action Alternative and existing conditions reflected by simulated flow changes are minimal. San Joaquin River and tributary flows would be similar to flows under existing conditions. In the Mokelumne and Tuolumne Rivers, short-term flows may be altered to improve spawning and rearing conditions, providing a beneficial impact primarily for chinook salmon. Extended flows during April-May could provide benefits to San Joaquin River species present in spring of some years. However, flow provided for the VAMP could reduce reservoir storage, reducing flow in some months and potentially increasing water temperature during summer and fall—with possible adverse effects on spawning chinook salmon and rearing steelhead juveniles.

Water quality conditions in most rivers in the San Joaquin River Region under the No Action Alternative would be similar to water quality conditions under existing conditions. The retirement of 35,000-45,000 acres of agricultural land could reduce input of contaminants to the San Joaquin River Region and improve the survival and spawning success of aquatic species, including chinook salmon and splittail. Change in contaminant effects, however, likely would be minimal.

Water quality conditions in most rivers in the San Joaquin River Region under the No Action Alternative would be similar to water quality conditions under existing conditions.

6.1.6.5 Other SWP and CVP Service Areas

The 2020 level of development under the No Action Alternative, including increased exports from the SWP and CVP Delta facilities, may assist growth in the Other SWP and CVP Service Areas. Additional agricultural or urban development would adversely affect aquatic ecosystems in the service areas, especially through increased input of contaminants. ESA limitations on QWEST and extension of VAMP, however, could slightly reduce exports relative to existing conditions, avoiding increased adverse impacts.

Additional agricultural or urban development would adversely affect aquatic ecosystems in the service areas, especially through increased input of contaminants.

MWD's Eastside Reservoir Project would create additional habitat for reservoir species. The Coastal Aqueduct and MWD's Inland Feeder Project transport Delta water to streams, reservoirs, and estuaries outside the Central Valley. Introduction and establishment of non-native species to areas currently isolated from the Central Valley may adversely affect native species communities through increased competition for resources, predation, and disease. Imported water also may alter seasonal flow patterns, possibly increasing summer flow through increased runoff in storm drains. Increased flow relative to natural conditions could improve habitat for introduced species and stress native species that are adapted to natural flow regimes.

6.1.7 CONSEQUENCES: PROGRAM ELEMENTS COMMON TO ALL ALTERNATIVES

The No Action Alternative is the environmental baseline against which the expected ecosystem and species response to the Program elements are compared. The differences between the No Action Alternative and the Program alternatives result from implementation of the Ecosystem Restoration, Water Quality, Levee System Integrity, Water Use Efficiency, Water Transfer, and Watershed Programs. In addition, new water storage might be constructed. Storage facilities could include groundwater and surface water components.

Impacts on the aquatic ecosystem are described for each Program element. Implementation of elements common to all alternatives included in the Program will be progressive, depending on achievement of the Program objectives and conformance to solution principles. The impacts will change as the Program moves forward, and impact occurrence will depend on the extent to which each Program element is implemented. Because of the complexity of the aquatic ecosystem, response to implementation of Program elements represented by the impacts on the aquatic ecosystem identified below is often uncertain. Resolution of the controversy resulting from uncertainty was previously discussed (see Section 6.1.2, "Areas of Controversy").

Implementation of elements common to all alternatives included in the Program will be progressive, depending on achievement of the Program objectives and conformance to solution principles. The impacts will change as the Program moves forward, and impact occurrence will depend on the extent to which each Program element is implemented.

6.1.7.1 DELTA REGION

Ecosystem Restoration Program

The goal of the Ecosystem Restoration Program is to improve and increase aquatic and terrestrial habitats, and to improve ecological functions in the Bay-Delta, in order to support sustainable populations of diverse and valuable plant and animal species (see the Ecosystem Restoration Program Plan). The program aims to restore ecosystem processes in order to (1) create and maintain habitat essential to species dependent on the Delta; and (2) reduce the adverse effects of stressors that inhibit ecosystem processes, limit habitat, and reduce species productivity. A Strategic Plan is being developed to guide implementation of the Ecosystem Restoration Program, including the type and intensity of actions needed to achieve Program targets.

The Ecosystem Restoration Program includes elements in four broad categories: ecosystem processes, habitats, species and species groups, and stressors. Ecosystem processes act directly, indirectly, or in combination to shape and form the ecosystem. Habitats are areas occupied by plants, fish, and wildlife that provide specific conditions essential to the needs of plant and animal communities. Species and species groups include species listed or proposed for listing under the California or federal ESAs, species of special concern as designated by the California Department of Fish and Game (DFG) or theUSFWS, species important in recreational or commercial fisheries, and important prey or foodweb species. Stressors are natural and unnatural events or activities that adversely affect ecosystem processes, habitats, and species.

The Ecosystem Restoration Program includes elements in four broad categories: ecosystem processes, habitats, species and species groups, and stressors.

In the Delta, actions addressing ecosystem processes are proposed to improve stream flows, natural sediment supply, natural floodplains and flood processes, stream temperatures, channel hydraulics, and the aquatic foodweb. Restored or reestablished habitat benefitting aquatic species would include tidal perennial aquatic habitat, nontidal perennial aquatic habitat, sloughs, midchannel islands and shoals, fresh emergent wetland, seasonal wetlands, and riparian and riverine aquatic habitats. Species-specific actions would target delta smelt, longfin smelt, splittail, white and green sturgeon, chinook salmon, steelhead, striped bass, American shad, resident fish species, and aquatic foodweb organisms. The primary stressors reduced by Program actions would include water diversions; effects of levees, bridges, and bank protection; dredging and sediment disposal; non-native species; predation and competition; contaminants; harvest; and human disturbance (for example, recreational boating).

Implementation of the Ecosystem Restoration Program would reactivate and maintain ecological processes and structures that sustain healthy fish, wildlife, and plant populations. The program is expected to increase the abundance and distribution of desired aquatic species, possibly including delta smelt, sturgeon, chinook salmon, and steelhead. The Delta would benefit from Ecosystem Restoration Program elements implemented upstream in the Sacramento River and San Joaquin River Regions and downstream in the Bay Region. River flows move sediment, nutrients, contaminants, and organisms to the Delta; and bi-directional tidal flow intimately connects Delta and Bay environments. Phased implementation integrated with adaptive management would avoid or minimize adverse impacts on aquatic communities and desired species, and guide the type and intensity of actions needed to achieve Program targets.

Implementation of the Ecosystem Restoration Program would reactivate and maintain ecological processes and structures that sustain healthy fish, wildlife, and plant populations. The program is expected to increase the abundance and distribution of desired aquatic species, possibly including delta smelt, sturgeon, chinook salmon, and steelhead.

A primary action includes restoration of aquatic areas—possibly several thousand acres—through breaching levees, flooding existing agricultural lands, and setting back levees along existing Delta channels. The conversion of some Delta islands from agricultural use to inundated wetlands and open-water habitat would markedly increase the abundance of aquatic habitat for Delta species. If restored areas are located near export facilities, are isolated from existing aquatic habitat, or provide depth or salinity unsuitable for important Delta species, the habitat value may be minimal. Under the existing Delta configuration, habitat restored in the south Delta potentially has the least value to Delta species because of their potential entrainment in Delta diversions. Increased flooded area in the central Delta also may be of minimal habitat value to many species because of the effects of diversion and export, and also because setting back levees and flooding of Delta islands would create primarily deep-water conditions. More extensive restoration actions that reduce water depth and increase channel complexity also could increase the habitat value of deep-water areas.

Restoration of aquatic areas also must consider contaminant concentrations in affected habitats and the potential for aquatic organisms to accumulate, magnify, transform, and mobilize contaminants to the detriment of aquatic communities or individual organisms. Effects of contaminants associated with habitat restoration, however, are considered a less-than-significant impact. Restoration programs would include components to identify problem areas and to either avoid contaminated areas or remove contaminants accumulated in sediment or vegetation.

Restored habitats in the north Delta are farthest from the export facilities, potentially include more shallow-water habitat with greater channel complexity, and are near existing more natural habitat. In addition, production from north Delta habitat is more likely to contribute to production in habitats downstream, in the Suisun Marsh and the Bay. Because the location of restoration actions and the characteristics of the flooded habitat are not known, it is difficult to assess the benefits to individual Delta species. New spawning and rearing habitat may be provided for resident species in the Delta, such as delta smelt, Sacramento splittail, Sacramento blackfish, Sacramento pikeminnow, tule perch, largemouth bass, and white catfish. Anadromous species, such as striped bass, chinook salmon, steelhead, American shad, and white sturgeon, also may benefit from the availability of additional juvenile rearing and adult habitat. However, newly created habitat also may increase the abundance and distribution of carp, inland silverside, or other non-native species that compete with or prey on native species and species with higher economic and social value (for example, chinook salmon, delta smelt, and striped bass). Although it is hoped that habitat restoration would provide benefits to target species, this potentially significant impact may be unavoidable.

New spawning and rearing habitat may be provided for resident species in the Delta, such as delta smelt, Sacramento splittail, Sacramento blackfish, Sacramento pikeminnow, tule perch, largemouth bass, and white catfish.

Construction activities associated with habitat restoration could result in adverse impacts through disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All Delta species could be affected, depending on the timing and location of construction relative to species occurrence. These potentially significant impacts can be mitigated to less-than-significant levels.

Actions designed to reduce illegal harvest and improve sport harvest management for anadromous fish would increase the survival of adult fish and reduce impacts on self-sustaining natural populations. The existing DFG Delta-Bay Enhanced Enforcement Program (DBEEP) provides enhanced law enforcement for illegal harvest of striped bass, salmon, steelhead, and sturgeon. Additional actions include improving harvest regulations, supplementing existing law enforcement efforts and community outreach, and developing additional cooperative programs to increase public awareness and provide additional means for reporting illegal-harvest violations. Species likely to benefit from such actions in the Delta Region include striped bass, chinook salmon, and sturgeon.

Actions designed to reduce illegal harvest and improve sport harvest management for anadromous fish would increase the survival of adult fish and reduce impacts on self-sustaining natural populations.

Water Quality Program

The Water Quality Program consists of actions designed to improve water quality in the Bay-Delta system and support all beneficial uses, including the protection and enhancement of aquatic life. The program relies on source control, increased enforcement of existing regulatory programs, and provision of incentives for action that goes beyond current regulatory programs. Potential actions would address contaminants from mine drainage, urban and industrial runoff, wastewater and industrial discharge, agricultural drainage and runoff, and unknown origins (for example, toxicity events affecting aquatic organisms that cannot be attributed to specific causes). Water quality parameters potentially affecting beneficial uses include metals and toxic elements, organics and pesticides, ammonia, dissolved oxygen, chloride, nutrients, alkalinity, turbidity, temperature, and salinity.

The Water Quality Program would reduce contaminant delivery and movement within the system, reactivating and maintaining ecological processes and structures that sustain healthy fish, wildlife, and plant populations.

Receiving contaminants from river inflow and bi-directional tidal flow from the Bay, the Delta would benefit from Water Quality Program elements implemented upstream in the Sacramento River and San Joaquin River Regions and downstream in the Bay Region. In addition to actions identified for the Delta, improved source control and treatment of mine drainage; reduced scour of metal-laden sediments; and watershed actions, including improved land use practices, would reduce the movement of contaminants into the Delta system.

The Water Quality Program would reduce contaminant delivery and movement within the system, reactivating and maintaining ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Reduced contaminants could substantially increase system productivity, reestablishing basic energy and material transfer mechanisms through increased survival, growth and reproduction. Although available information is insufficient to develop specific impact conclusions for individual species, many species would benefit from reduced metabolic stress and increased survival.

Levee System Integrity Program

The Levee System Integrity Program would reduce the risk to the ecosystem of catastrophic breaching of Delta levees by maintaining and improving the integrity of the levee system. Reduced likelihood of catastrophic breaching of Delta levees would reduce the likelihood of rapid hydrodynamic and salinity changes caused by sudden changes in Delta outflow and channel flow conditions. Although infrequently, species would benefit from the reduced frequency of sudden salinity shifts that could adversely affect habitat or delay transport to areas providing for specific species needs, such as spawning and rearing habitat. The change in flow and water quality conditions attributable to catastrophic breaching of levees also could increase entrainment in Delta diversions, depending on the change in the distribution of a species and the timing of breach relative to the vulnerability of specific life stages. Reduced risk of catastrophic breaching would reduce the risk of unexpected increased entrainment events.

Although infrequently, species would benefit from the reduced likelihood of sudden salinity shifts that could adversely affect habitat or delay transport to areas providing for specific species needs, such as spawning and rearing habitat.

Setting back levees and constructing channel-side berm and levee remnants, if implemented to maintain and improve Delta levee integrity, have great potential to improve the aquatic and riparian habitat characteristics of the Delta, Bay, Sacramento River, and San Joaquin River Regions when the substrate is stabilized and vegetation is restored. Changes in levee maintenance practices to allow development of natural riparian and marsh communities also would produce beneficial effects on aquatic and riparian habitat characteristics. Levee reconstruction, dredging, and the installation of rock revetment would result in both short- and long-term adverse effects due to habitat encroachment and losses. Construction activities could result in potentially significant adverse impacts though disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All Delta species could be affected, depending on the timing and location of construction relative to species occurrence. These potentially significant impacts can be mitigated to less-than-significant levels.

Setting back levees and constructing channel-side berm and levee remnants, if implemented to maintain and improve Delta levee integrity, have great potential to improve the aquatic and riparian habitat characteristics of the Delta, Bay, Sacramento River, and San Joaquin River Regions when the substrate is stabilized and vegetation is restored.

Water Use Efficiency Program

The Water Use Efficiency Program could increase net water savings through implementation of conservation and water recycling actions. Net water savings could reduce the demand for Delta exports, increase water available for transfers, delay the need for new water facilities, and improve water quality. Reduced demands could increase reservoir and diversion operation flexibility, and allow flow management to meet species needs or to more closely approximate the natural seasonal flow variability (pattern and magnitude), including the effects of Delta outflow on seasonal variability in salinity distribution. Reestablishing natural seasonal flow variability (pattern and magnitude) could reactivate and maintain ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Reduced contaminant delivery as a result of reduced applied water and subsequent reduced runoff would improve water quality, potentially reactivating and maintaining ecological processes that sustain healthy aquatic communities. Improved water quality also could increase productivity.

Reduced demands could increase reservoir and diversion operation flexibility, and allow flow management to meet species needs or to more closely approximate the natural seasonal flow variability (pattern and magnitude), including the effects of Delta outflow on seasonal variability in salinity distribution.

Species would benefit from reduced entrainment and impingement impacts that are associated with reduced diversions, modifications in flow timing and reservoir releases, improved in-stream water quality, and increased water available for ecosystem purposes.

Water Transfer Program

The Water Transfer Program could provide the incentive to implement practices that increase water use efficiency and subsequent availability of water for transfer. Impacts of the Water Use Efficiency Program are discussed above. Water transfers would affect fisheries and aquatic resources primarily through changes to riverine flow and export. Several factors, including the source of water for a transfer and the timing, magnitude, and pathway of each transfer, affect the potential for potentially significant impacts. To the extent that transfers are consistent with ecosystem needs and purposes, fisheries and aquatic ecosystems would benefit. Benefits could include reestablishing the natural

The Water Transfer Program could provide the incentive to implement practices that increase water use efficiency and subsequent availability of water for transfer.

seasonal flow and salinity variability, and reduced entrainment and impingement impacts associated with reduced or rescheduled diversions.

Potentially significant adverse impacts may result from transfers between agricultural and urban uses if proper planning and management of specific transfers are not undertaken. At the ecosystem level, transfers may affect seasonal flow variability and productivity. Adverse effects on species could include reduced habitat abundance attributable to flow effects, reduced transport and attraction in response to flow effects, and increased entrainment attributable to flow effects on species movement and distribution (for example, species response to change in estuarine salinity) relative to the location and volume of diversions.

Watershed Program

The Watershed Program could affect all of the programs described above. Watershed activities would focus on reducing stressors; and encompassing natural and unnatural events or activities that adversely affect ecosystem processes, habitats, and species. Actions could include stream bank restoration, slope stabilization, meadow restoration, point source contaminant control, and aquatic habitat restoration. Implementation of actions could improve water quality, increase species habitat, increase water availability, and restore the natural stream structure.

Ecosystem-level benefits could include a closer approximation of natural seasonal flow (and salinity) variability, restoration of natural sediment delivery and movement, reduced contaminant input, increased productivity, and restoration of the natural ecosystem structure.

Most of the impacts in the Delta Region would result from activities in the Sacramento River and San Joaquin River Regions. Many potential watershed activities that are expected to improve water quality and flows in those regions also would improve water quality and flows in the Delta. Ecosystem-level benefits could include a closer approximation of natural seasonal flow (and salinity) variability, restoration of natural sediment delivery and movement, reduced contaminant input, increased productivity, and restoration of the natural ecosystem structure, such as floodplain connectivity. Species benefits primarily would accrue from increased habitat abundance due to improved flow conditions and increased survival, growth, and reproduction in response to improved water quality.

Storage

New storage would provide the opportunity for additional flow management, potentially affecting the magnitude, timing, and duration of Delta inflow, Delta outflow, and exports. New storage would be constructed and operated only after information clearly confirms that potentially significant adverse impacts on fish and aquatic species populations can be avoided.

New storage would provide the opportunity for additional flow management, potentially affecting the magnitude, timing, and duration of Delta inflow, Delta outflow, and exports.

New storage could change Delta inflow and outflow. Relative to the natural seasonal flow variability (pattern and magnitude), however, simulated flows with new storage were similar to flows under the No Action Alternative. Actual effects will need to be determined for specific projects and will depend on location (for example, upstream of

Delta, in-Delta, offstream, or existing reservoir enlargement) and operations rules. A portion of new storage may be allocated to environmental water supplies and could provide beneficial impacts through enhancement of seasonal flow needs for biological communities and species in the Delta. Species could benefit from increased productivity and improved conditions affecting movement. Total Delta outflow, however, would be reduced because of additional export. The adverse effects of reduced outflow, including the effects on estuarine salinity, would depend on timing and reduction in magnitude relative to base outflow conditions.

Simulated operations demonstrated that increased storage could enable average annual CVP and SWP exports to increase by 500-700 TAF (an 8-12% annual increase). The simulated increase primarily occurs during January-March and in September. Higher exports could adversely affect the population abundance of Delta species through increased entrainment-related losses, including losses of winter-, spring-, and fall-run chinook salmon and adult delta smelt. In addition, increased exports would increase the magnitude of net reverse flow conditions in Old and Middle Rivers and possibly in the lower San Joaquin River. Net reverse flow conditions are counter to natural net flow conditions in Delta channels and could reduce productivity, impair species movement, and increase entrainment in Delta diversions. Species adversely affected could include chinook salmon, steelhead, delta smelt, and striped bass.

Mitigation is available to reduce these potentially significant flow-related impacts to less-than-significant levels. However, mitigation potentially includes operational changes that could reduce water availability for other beneficial uses identified in Section 5.1, "Water Supply and Water Management."

Construction of storage facilities in the Delta could cause adverse impacts though disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All Delta species could be affected, depending on the timing and location of construction relative to species occurrence.

6.1.7.2 BAY REGION

Ecosystem Restoration Program

Implementation of the Ecosystem Restoration Program would reactivate and maintain ecological processes and structures that sustain healthy fish, wildlife, and plant populations. The Program also would increase the abundance and distribution of desired estuarine and anadromous species.

The Bay ecosystem would benefit from Ecosystem Restoration Program elements implemented in the Delta and upstream of the Delta. River flows move sediment, nutrients, contaminants, and organisms to the Bay; and bi-directional tidal flow intimately connects Delta and Bay environments.

In the Bay, actions addressing ecosystem processes are proposed to improve stream flows, natural floodplains and flood processes, and the aquatic foodweb. Restored or reestablished habitat benefitting aquatic species would include tidal perennial aquatic habitat, nontidal perennial aquatic habitat, sloughs, saline emergent wetland, seasonal wetlands, and riparian and riverine aquatic habitats. Species-specific actions would target delta smelt, longfin smelt, splittail, white and green sturgeon, chinook salmon, steelhead, striped bass, American shad, resident fish species, estuarine foodweb organisms, and marine and estuarine fishes and large invertebrates. The primary stressors reduced by Program actions would include water diversions, non-native species, predation and competition, contaminants, harvest, and human disturbance (for example, recreational boating).

Implementation of the Ecosystem Restoration Program would reactivate and maintain ecological processes and structures that sustain healthy fish, wildlife, and plant populations. The Program also would increase the abundance and distribution of desired estuarine and anadromous species, including delta smelt, sturgeon, chinook salmon, and steelhead. Phased implementation integrated with adaptive management would avoid or minimize adverse impacts on aquatic communities and desired species, and guide the type and intensity of actions needed to achieve Program targets.

Restoration of aquatic and adjacent communities, including riparian, shallow water, and tidal marsh, would increase productivity through the increased input of organic carbon. Increased production would result from the increased area available to support plants, including algae and vascular plants, and the increased density of plants in restored habitats. Increased inputs may result from reestablishing connections between terrestrial and aquatic habitats.

Restoration of aquatic and adjacent communities, including riparian, shallow water, and tidal marsh, would increase productivity through the increased input of organic carbon.

Restoration of aquatic areas also must consider contaminant concentrations in affected habitats and the potential for aquatic organisms to accumulate, magnify, transform, and mobilize contaminants to the detriment of aquatic communities or individual organisms. Effects of contaminants associated with habitat restoration, however, are considered a less-than-significant impact. Restoration programs would include components to identify problem areas and to either avoid contaminated areas or remove contaminants accumulated in sediment or vegetation.

The conversion of some managed wetlands to inundated tidal wetlands and open-water habitat would markedly increase the abundance of aquatic habitat for Bay species. The habitat value of newly inundated areas for Bay species would vary greatly, depending on the location and morphological characteristics of the restored areas. New spawning and rearing habitat may be provided for resident species in the Bay and Suisun Marsh, such as longfin smelt and striped bass. Anadromous species, such as chinook salmon, steelhead, and white sturgeon, also may benefit from the increased abundance of juvenile rearing and adult habitat. Benefits to existing and reestablished habitat would be enhanced by actions to control non-native invasive species (although, specific actions are currently undetermined) and to increase the effectiveness of programs that reduce the introduction of invasive species.

Benefits to existing and reestablished habitat would be enhanced by actions to control the abundance of non-native invasive species and to increase the effectiveness of programs that reduce the introduction of invasive species.

Construction activities associated with habitat restoration could result in adverse impacts through disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All Bay species could be affected, depending on the timing and location of construction relative to species occurrence. Mitigation is available to reduce these potentially significant impacts to less-than-significant levels.

Artificial production targets in the Ecosystem Restoration Program include managing artificial fish propagation programs consistent with the rehabilitation of naturally producing populations, conserving ecological and genetic values, achieving recovery of special-status species, and maintaining healthy populations of other species. In general, these actions could benefit delta smelt, chinook salmon, steelhead, and other species in the Bay Region (primarily through reduced predation and competition effects).

Actions in the Ecosystem Restoration Program designed to reduce illegal harvest and improve sport harvest management for anadromous fish would increase the survival of adult fish and reduce impacts on self-sustaining natural populations. Additional actions include improving harvest regulations, supplementing existing law enforcement efforts and community outreach (DBEEP), and developing additional cooperative programs to increase public awareness and provide additional means for reporting illegal-harvest violations. Species likely to benefit from such actions in the Bay Region include striped bass, chinook salmon, and sturgeon.

Actions in the Ecosystem Restoration Program designed to reduce illegal harvest and improve sport harvest management for anadromous fish would increase the survival of adult fish and reduce impacts on self-sustaining natural populations.

Water Quality Program

Program elements implemented in the Bay Region would address contaminants introduced from wastewater and industrial discharge, and from unknown origins (for example, toxicity events affecting aquatic organisms that cannot be attributed to specific causes). Beneficial impacts described above for the Delta would be similar for the Bay ecosystem and species. In addition, contaminants entering the Delta potentially flow to the Bay; therefore, the Bay would benefit from Water Quality Program elements implemented upstream in the Sacramento River and San Joaquin River Regions and in the Delta Region.

Levee System Integrity Program

Although the Levee System Integrity Program would not directly affect most Bay environments, the reduced likelihood of catastrophic breaching of Delta levees would reduce the likelihood of rapid hydrodynamic and salinity shifts caused by sudden change in Delta outflow. Although infrequently, species would benefit from the reduced frequency of sudden salinity shifts that could adversely affect habitat or delay transport to areas providing for specific species needs, such as spawning and rearing habitat. As in the Delta, setting back levees and constructing channel-side berm and levee remnants as part of levee maintenance and improvement in Suisun Marsh would allow development of natural marsh communities and produce beneficial effects on aquatic habitat characteristics. Levee reconstruction, dredging, and the installation of rock revetment would result in both short- and long-term adverse effects due to habitat encroachment and losses. Construction activities could result in potentially significant adverse impacts though disturbance of existing biological communities, mobilization of sediments, and input of contaminants. These potentially significant impacts can be mitigated to less-than-significant levels.

Species benefits would primarily accrue from increased habitat abundance due to improved flow conditions and increased survival, growth, and reproduction in response to improved water quality.

Water Use Efficiency Program

Benefits described for Water Use Efficiency Program actions in the Delta Region also would apply to the Bay Region, primarily through contributions to reestablishing the natural seasonal variability in Delta outflow and salinity distribution.

Water Transfer Program

Impacts of Water Transfer Program elements in the Bay would be similar to impacts described for the Delta, primarily caused by actions affecting natural seasonal Delta outflow and salinity variability.

Watershed Program

As described for the Delta, benefits to the Bay would result from watershed activities in the Sacramento River and San Joaquin River Regions. Many potential watershed actions that are expected to improve water quality and flows in the upper watershed areas also would improve water quality and flows in the Bay. Ecosystem-level benefits could include closer approximation of natural seasonal flow (and salinity) variability, restoration of natural sediment delivery and movement, reduced contaminant input, increased productivity, and restoration of natural ecosystem structure. Species benefits would primarily accrue from increased habitat abundance due to improved flow conditions and increased survival, growth, and reproduction in response to improved water quality.

Many potential watershed actions that are expected to improve water quality and flows in the upper watershed areas also would improve water quality and flows in the Bay.

Storage

New storage could change Delta outflow; however, relative to natural seasonal flow variability (pattern and magnitude), simulated flows with new storage were similar to flows under the No Action Alternative. As described for the Delta Region, actual effects will need to be determined for specific projects. The portion of new storage that may be allocated to environmental water supplies could provide beneficial impacts through enhancement of seasonal flow needs for biological communities and species in the Bay. Total annual Delta outflow, however, could be reduced because of additional export and could adversely affect Bay species.

The portion of new storage that may be allocated to environmental water supplies could provide beneficial impacts through enhancement of seasonal flow needs for biological communities and species in the Bay.

The adverse effects of reduced annual outflow, including effects on estuarine salinity, would depend on the timing and reduction in magnitude relative to base outflow conditions. For some species, higher abundance is associated with higher Delta outflow. Delta outflow is the primary determinant of estuarine salinity distribution. Salinity affects a multitude of ecological processes, including those influencing the distribution and abundance of some aquatic organisms. Changes in Delta outflow that result in salinity distribution more closely approximating the natural seasonal pattern were assumed to restore salinity-related processes in the Bay and to benefit species through increased habitat, improved water quality, and other mechanisms. Mitigation is available to reduce these potentially significant impacts to less-than-significant levels, although mitigation potentially includes operational changes that could reduce water availability for other beneficial uses identified in Section 5.1, "Water Supply and Water Management."

6.1.7.3 SACRAMENTO RIVER AND SAN JOAQUIN RIVER REGIONS

Ecosystem Restoration Program

Actions addressing ecosystem processes are proposed to improve stream flows (including short-term flow fluctuations), natural sediment supply, stream meander, natural floodplains and flood processes, stream temperatures, and watershed processes (for example, wildfire; erosion; and management of timber harvest, grazing, and land use practices). Restored or reestablished habitat benefitting aquatic species would include seasonal wetlands and riparian and riverine aquatic habitats. Species-specific actions would target splittail, white and green sturgeon, chinook salmon, steelhead, striped bass, American shad, and resident fish species. The primary stressors reduced by Program actions would include water diversions; dams, weirs, reservoirs, and other structures; levees, bridges, and bank protection; gravel mining; non-native species; predation and competition; contaminants; harvest; artificial production; and human disturbance (for example, recreational boating).

Implementation of the Ecosystem Restoration Program would reactivate and maintain the ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Program actions would increase the abundance and distribution of desired anadromous species, including chinook salmon, steelhead, and splittail. Phased implementation integrated with adaptive management would avoid or minimize adverse impacts on aquatic communities and desired species, and guide the type and intensity of actions needed to achieve Program targets.

Reduced entrainment-related losses will increase species abundance and distribution. Approaches to reduce entrainment losses include the removal or relocation of high-impact diversions, changes in diversion timing to avoid periods of high species sensitivity, and construction of positive-barrier fish screens.

Ecosystem Restoration Program actions could lessen existing adverse stream water temperature conditions in the Sacramento River and San Joaquin River Regions. Increased riparian shading and natural channel configurations, especially on small tributary streams, would provide stream temperatures that approximate more natural conditions. On rivers where access to cool-water habitat has been blocked by dams, management actions will be required to maintain adequate cool-water habitat abundance within accessible reaches. Management actions may include revised carry-over storage requirements for upstream reservoirs, appropriate and enforceable water temperature requirements in downstream reaches, temperature control devices on reservoir outlets, and development of flexible

Ecosystem Restoration Program actions could lessen existing adverse stream water temperature conditions in the Sacramento River and San Joaquin River Regions. Increased riparian shading and natural channel configurations, especially on small tributary streams, would provide stream temperatures that approximate more natural conditions.

short- and long-term flow management strategies. Chinook salmon and steelhead are the primary species that would benefit from improved water temperature conditions.

Restoration of the floodplain and floodplain processes would increase nutrient flows from terrestrial zones to the aquatic ecosystem, and increase biological productivity. Meander zones would increase the combined length of interfacing between terrestrial and aquatic zones, and restore the dynamic sediment movement processes that are critical to maintenance of diverse biological communities. Riparian restoration would increase the input of terrestrial invertebrates and nutrients into the stream system. Restoration of natural surface features would promote the development of additional channel complexity. Natural sediment input and movement processes also would benefit from reduced in-stream gravel extraction if these activities are relocated outside active stream channels and riparian zones. Introducing gravel into deficient areas (for example, below dams where natural sediment input cannot be restored) may reestablish sediment movement and habitat for desired species.

Construction of Ecosystem Restoration Program elements could cause short-term adverse impacts though disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All aquatic species could be affected, depending on the timing and location of construction relative to species occurrence. Mitigation is available to reduce these potentially significant impacts to less-than-significant levels.

For chinook salmon, steelhead, and possibly other species, artificial production actions in the Ecosystem Restoration Program would be designed to avoid adverse effects on the fitness of natural spawning and rearing populations, ultimately increasing the abundance and distribution of target populations. Fish propagation programs would be consistent with rehabilitating the naturally producing populations, conserving ecological and genetic values, achieving the recovery of special-status species, and maintaining healthy populations of other species.

For chinook salmon, steelhead, and possibly other species, artificial production actions in the Ecosystem Restoration Program would be designed to avoid adverse effects on the fitness of natural spawning and rearing populations, ultimately increasing the abundance and distribution of target populations.

Chinook salmon and steelhead are the primary species targeted by actions to reduce illegal harvest and improve sport harvest management. Ecosystem Restoration Program harvest management elements would be consistent with maintaining the fitness of the natural spawning and rearing populations. Program elements may include additional actions improving harvest regulations, supplementing existing law enforcement efforts and community outreach (DBEEP), and developing additional cooperative programs to increase public awareness and provide additional means for reporting illegal-harvest violations.

Water Quality Program

In the Sacramento River and San Joaquin River Regions, the Water Quality Program relies on source control, increased enforcement of existing regulatory programs, and provision of incentives for action that exceed current regulatory programs. Potential actions would address contaminants from mine drainage, urban and industrial runoff, wastewater and industrial discharge, agricultural drainage and runoff, and unknown origins (for example, toxicity events affecting aquatic organisms that cannot be attributed to other causes). Water quality parameters potentially affecting beneficial uses include metals and toxic elements, organics and pesticides, ammonia, dissolved oxygen, chloride, nutrients, alkalinity, turbidity, temperature, and salinity.

The Water Quality Program would reduce contaminant delivery and movement within the system, reactivating and maintaining ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Reduced contaminants could substantially increase system productivity, reestablishing basic energy and material transfer mechanisms through increased survival, growth, and reproduction. Although available information is insufficient to develop specific impact conclusions for individual species, many species would benefit from reduced metabolic stress and increased survival.

The Water Quality Program would reduce contaminant delivery and movement within the system, reactivating and maintaining ecological processes and structures that sustain healthy fish, wildlife, and plant populations.

Levee System Integrity Program

Actions included in the Levee System Integrity Program would minimally affect fisheries and the aquatic ecosystems in the Sacramento River and San Joaquin River Regions. The reduced frequency of catastrophic levee failure in the Delta could benefit these resources through reduced use of reservoir storage to restore the salinity balance in the Delta. Reservoir storage retained upstream would avoid the loss of operations flexibility, reducing the probability of unexpected adverse water temperature and flow effects.

Net water savings could increase flexibility in reservoir operations, reduce diversions, improve water quality, delay the need for new water facilities, and increase the amount of water available for transfers.

Water Use Efficiency Program

The Water Use Efficiency Program could increase net water savings through implementation of conservation and water recycling actions. Net water savings could increase flexibility in reservoir operations, reduce diversions, improve water quality, delay the need for new water facilities, and increase the amount of water available for transfers.

Increased reservoir operation flexibility may allow flow management that more closely approximates the natural seasonal flow pattern and could increase the availability of cool-water releases to meet the needs of desired biological communities. Reestablishing natural seasonal flow pattern and magnitude could reactivate and maintain ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Increased flexibility in flow management also may allow operations to minimize water level fluctuation. Improved habitat conditions (for example, improved water temperature and reduced stranding) could benefit all species, including chinook salmon and steelhead.

Reestablishing natural seasonal flow pattern and magnitude could reactivate and maintain ecological processes and structures that sustain healthy fish, wildlife, and plant populations.

Diversions would be reduced in response to the reduced demands resulting from increased water use efficiency. Water use efficiency actions also are expected to alter the timing and pattern of diversions to avoid existing entrainment or other fisheries impacts. Lower diversions, depending on their timing relative to species occurrence, could reduce entrainment losses and benefit species abundance. Improved water quality would result from reduced contaminant delivery to the river system. Reduced contaminant delivery as a result of reduced applied water and the subsequent reduced runoff potentially would increase the productivity and survival of aquatic organisms. Delaying the need for new water facilities could avoid (1) additional adverse effects on seasonal flow variability; and (2) adverse impacts on natural structural features, including the loss of aquatic species habitat upstream of dams on currently unconstrained systems. Delaying the need for new water facilities also could avoid adverse impacts on species habitat.

Although increased water use efficiency generally would benefit the ecosystem processes and species in the Sacramento River and San Joaquin River Regions, adverse impacts may occur if the timing of reservoir releases is inconsistent with species needs or if runoff of applied water is reduced below the needs of existing wetlands and riparian habitats. These potential impacts are expected to be avoided or mitigated through coordinated operations.

Water Transfer Program

Water transfers have the potential for both beneficial and adverse impacts on in-stream seasonal flows and on water temperature and quality. The transfer of water from storage facilities, if not appropriately timed, could adversely affect the immediate downstream habitat by reducing water available for release at a subsequent time during the season. However, the same transfer, if properly timed, could benefit downstream ecosystem conditions. This is especially true if the transfer is being executed for in-stream flow purposes.

Most water transferred for another consumptive use, regardless of the source of water being transferred, has the potential to be timed to provide a benefit to tributaries and main streams of the Sacramento and San Joaquin Valleys. Since most of these transfers need to be approved by state or federal agencies with mandates to ensure that environmental effects are minimized, the potential for adverse effects from transfers to fishery and aquatic ecosystems is generally not present.

Most water transferred for another consumptive use, regardless of the source of water being transferred, has the potential to be timed to provide a benefit to tributaries and main streams of the Sacramento and San Joaquin Valleys.

Watershed Program

Watershed activities could affect all of the programs described above. The Watershed Program would focus on reducing stressors, encompassing natural and unnatural events or activities that adversely affect ecosystem processes, habitats, and species. Actions could include stream bank restoration, slope stabilization, meadow restoration, point source contaminant control, and aquatic habitat restoration. Implementation of actions could improve water quality, increase species habitat, increase water availability, and restore the natural stream structure.

Potential watershed activities are expected to improve water quality and flows in the Sacramento River and San Joaquin River Regions. Ecosystem-level benefits could include closer approximation of natural seasonal flow (and salinity) variability, restoration of basic heat transfer and storage mechanisms with beneficial effects on water temperature, restoration of natural sediment delivery and movement, reduced contaminant input, increased productivity, and restoration of the natural ecosystem structure. Species benefits

Species benefits primarily would accrue from increased habitat abundance (attributable to improved flow and water temperature conditions) and increased survival, growth, and reproduction in response to improved water quality.

primarily would accrue from increased habitat abundance (attributable to improved flow and water temperature conditions) and increased survival, growth, and reproduction in response to improved water quality.

Construction of Watershed Program elements could cause short-term adverse impacts though disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All aquatic species could be affected, depending on the timing and location of construction relative to species occurrence. These impacts are expected to be less than significant.

Storage

New storage would provide the opportunity for additional flow management—potentially affecting the magnitude, timing, and duration of stream flow and diversion. New storage would be constructed and operated only after information clearly confirms that potentially significant adverse impacts on fish and aquatic species populations can be avoided.

Simulated hydrology with new storage indicated that Sacramento River flow would increase during August-September and that minimal changes in flow would occur on the San Joaquin River and its tributaries. Relative to natural seasonal flow variability (pattern and magnitude), however, simulated flows with new storage were similar to the flow timing, duration, and magnitude under the No Action Alternative. Actual effects will need to be determined for specific projects and will depend on location (for example, upstream of Delta, in-Delta, offstream, onstream, or enlargement of an existing reservoir) and operations rules. A portion of new storage may be allocated to environmental water supplies and could provide benefits through enhancement of seasonal flow needs for biological communities and species in the Sacramento and San Joaquin Rivers. Species could benefit from increased habitat abundance attributable to improved flow and water temperature conditions.

Simulated hydrology with new storage indicated that Sacramento River flow would increase during August-September and that minimal changes in flow would occur on the San Joaquin River and its tributaries.

New surface storage reservoirs may be filled by diversions from the Sacramento and San Joaquin Rivers or their tributaries. Simulated diversions generally coincided with relatively high flow conditions, and the change in stream flow relative to conditions under the No Action Alternative was minimal. Diversions to off-stream storage, depending on the timing relative to species occurrence, could increase entrainment loss and adversely affect species populations, including chinook salmon and steelhead. These potentially significant impacts can be mitigated to less-than-significant levels, although mitigation potentially includes operational changes that could reduce water availability for other beneficial uses identified in Section 5.1, "Water Supply and Water Management."

New surface storage reservoirs may be filled by diversions from the Sacramento and San Joaquin Rivers or their tributaries. Simulated diversions generally coincided with relatively high flow conditions, and the change in stream flow relative to conditions under the No Action Alternative was minimal.

Development of new surface storage would create additional aquatic reservoir habitat. Extreme water surface-level fluctuations would be likely and, if they occur, they would limit the habitat values of the reservoirs for aquatic species.

Construction of storage facilities could cause short-term adverse impacts through disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All aquatic species could be affected, depending on the timing and location of construction relative to species occurrence. These potentially significant impacts can be mitigated to less-than-significant levels.

6.1.7.4 OTHER SWP AND CVP SERVICE AREAS

All Programs

Implementation of the Program elements common to all alternatives most likely would minimally affect fisheries and aquatic resources in streams, reservoirs, and estuaries in the Other SWP and CVP Service Areas. Organisms transported with imported water and the destination of the water would be the same as under the No Action Alternative. Actions in the Ecosystem Restoration Program that address the introduction of non-native species into the Bay-Delta system also would limit their introductions into areas receiving SWP and CVP water.

Actions in the Ecosystem Restoration Program that address the introduction of non-native species into the Bay-Delta system also would limit their introductions into areas receiving SWP and CVP water.

6.1.8 CONSEQUENCES: PROGRAM ELEMENTS THAT DIFFER AMONG ALTERNATIVES

For fisheries and aquatic ecosystems, the Conveyance element results in environmental consequences that differ among the alternatives, as described below.

Each Program alternative includes a different suite of Conveyance elements. The facilities could substantially change the way water moves through the Delta and under Alternatives 1, 2, and 3 may result in potentially significant unavoidable adverse impacts on fish and aquatic resources.

Under the Preferred Program Alternative, construction and operation of Program elements depend on the ability to avoid adverse impacts on fish and other aquatic species populations. Consequently, some of the elements discussed may not be constructed.

6.1.8.1 PREFERRED PROGRAM ALTERNATIVE

The impacts will change as the Program moves forward, and the degree of impacts will depend on the extent to which each conveyance element is implemented.

The Preferred Program Alternative includes a description of consequences of a pilot diversion project near Hood and channel modifications along the Mokelumne River and in the south Delta. The pilot diversion project may not be constructed because of uncertain species responses to the Program elements and subsequent potential for adverse impacts. The Program is committed to addressing uncertainty, and Program elements would be constructed and operated only after information clearly confirms that potentially significant adverse effects on fish and aquatic species populations can be avoided. Key to implementation of the Preferred Program Alternative is a strategy to address the uncertainty of species and ecosystem responses to Program elements. Ongoing activities to increase understanding of natural physical and biological processes and species habitats include the Strategic Plan for the CMARP, and development of a Conservation Strategy.

The pilot diversion project may not be constructed because of uncertain species responses to the Program elements and subsequent potential for adverse impacts.

To minimize and avoid potential adverse effects of changes in flow and diversion, construction and operation of new facilities (such as barriers, fish screens, and conveyance channels) may be preceded by focused studies to determine the environmental effects, including species population response. Actions may be implemented progressively over the long term, and actions would be integrated with monitoring and evaluation to assess effects on the aquatic ecosystem, achievement of the Program objectives, and conformance to Program solution principles.

Although adverse aquatic species population effects would be avoided, harm to individual organisms could result from certain aspects of the Program elements (for example, entrainment loss and migration delay). For special-status species, such as species listed under federal and California ESAs, harm to individual organisms and their habitat is considered a significant adverse impact. The Program has committed to developing mitigation strategies that will minimize potentially significant adverse impacts prior to construction and operation of Program elements.

Delta Region

Delta Cross Channel. Under the Preferred Program Alternative, the DCC may be closed from September through July and possibly all months. Flexible operations would be considered, depending on demonstrated benefits. Based on DCC operations under the No Action Alternative, potential operations for the Preferred Program Alternative would increase juvenile salmon survival entering the Delta from the Sacramento River during October-January and May 20-June 30. Closure could benefit winter-, spring-, late fall-, and fall-run chinook salmon, although peak migration of juvenile chinook from the Sacramento River generally occurs after October, depending on occurrence of storm events.

Under the Preferred Program Alternative, the DCC may be closed from September through July and possibly all months.

Additional closure of the DCC relative to conditions under the No Action Alternative may increase the frequency and magnitude of net reverse flow conditions in the lower San Joaquin River, although the potential diversion channel near Hood would minimize or override the effects of DCC closure. If net reverse flow conditions are worsened, the reduced frequency of natural net flow conditions in Delta channels could reduce productivity, impair species movement, and increase entrainment in Delta diversions. Species adversely affected could include delta smelt, striped bass, and American shad. Implementation of DCC operations would be contingent on development of operations criteria that have been demonstrated, through monitoring and focused studies, to avoid adverse effects.

Delta Channel Capacity. Old River north of CCFB may be enlarged to reduce channel velocity. The enlarged channel potentially allows use of the full capacity of the SWP Delta export facility when all Bay-Delta standards are met. Simulated operations indicate that full use of the SWP pump capacity could increase the total annual exports by approximately 4%. In the absence of the other elements of the Preferred Program Alternative, increased exports could increase the magnitude of net reverse flow conditions in Old and Middle Rivers, and possibly in the lower San Joaquin River. Net reverse flow conditions are counter to natural net flow conditions in Delta channels and could reduce productivity, impair species movement, and increase entrainment in Delta diversions. Total Delta outflow also would be slightly reduced because of the additional export. The adverse effects of reduced outflow, including effects on estuarine salinity, would depend on the timing and reduction in magnitude relative to base outflow conditions. Species adversely affected could include chinook salmon, steelhead, delta smelt, striped bass, and American shad. These potentially significant impacts would be avoided under the Preferred Program Alternative implementation strategy.

Dredging to enlarge channels could cause adverse impacts. Dredging would increase the channel depth and further alter the natural structural features. In the short term, dredging would remove benthic communities and mobilize fine sediments. Maintenance dredging may be required over the long term, resulting in periodic short-term impacts. Dredging also may cause levee instability, which could require additional revetment and levee maintenance activities. Levee maintenance could remove tidal marsh communities and riparian vegetation. Dredging would adversely affect channel structure, productivity, water quality, and species habitat. These potentially significant impacts can be mitigated to less-than-significant levels.

A new screened forebay intake would be constructed at the CCFB. The new facility could reduce entrainment losses relative to existing levels because fish entrainment into Clifton Court would be avoided and new state-of-the-art fish screens and associated facilities would increase screening efficiency.

South Delta Intake Facilities. A new screened forebay intake may be constructed at the CCFB. The new facility potentially reduces entrainment losses relative to existing levels because fish entrainment into Clifton Court would be avoided and new state-of-the-art fish screens and associated facilities would increase screening efficiency. Reduced losses would benefit chinook salmon, steelhead, striped bass, delta smelt, splittail, and other Delta species.

Construction of new intake facilities could result in potentially significant adverse impacts through disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All Delta species could be affected, depending on the timing of construction relative to species occurrence. These impacts can be mitigated to less-than-significant levels.

South Delta Flow Control Barriers. An operable barrier may be constructed on the head of Old River at the confluence with the San Joaquin River near Mossdale. When closed, the barrier would direct San Joaquin River flow down the main San Joaquin River channel and past Stockton. The barrier potentially benefits juvenile chinook salmon from the San Joaquin River, by directing their movement along the San Joaquin River pathway and away from the CVP and SWP south Delta export intakes. The barrier also may benefit adult chinook salmon through the improved dissolved oxygen and water temperature conditions that result from increased net flow past Stockton.

The barrier at the head of Old River could benefit juvenile chinook salmon from the San Joaquin River, by directing their movement along the San Joaquin River pathway and away from the CVP and SWP south Delta export intakes.

Closure of the barrier, without a concomitant reduction in exports, would increase net flow toward the CVP and SWP south Delta export intakes, primarily through Turner Cut, Middle River, and Old River. Net flow toward the export facilities counters the natural net flow conditions in Delta channels and could reduce productivity, impair species movement, and increase entrainment in Delta diversions. Species adversely affected could include chinook salmon, steelhead, delta smelt, striped bass, and American shad. Benefits to San Joaquin River chinook salmon identified in the preceding paragraph could be partially negated by this increase. Because of the uncertainty of existing information on response of species to south Delta barriers, these potentially significant impacts may be unavoidable. Implementation under the Preferred Program Alternative, however, would be contingent on development of operations criteria that have been demonstrated, through monitoring and focused studies, to avoid adverse effects.

Construction of barriers on other south Delta channels, such as Middle River and Old River near the CVP's Tracy fish facility, or their functional equivalent may be necessary to alleviate the reduced water levels caused by closure of the head of Old River barrier in combination with CVP and SWP export operation. The barriers would diminish tidal flow, reducing connectivity to other Delta channels and altering basic hydraulic features that affect sediment and nutrient movement, water quality conditions (for example, water temperature and dissolved oxygen), and productivity. Species could be adversely affected by loss of habitat, change in water quality conditions (including water temperature and dissolved oxygen), and impeded access to resources and conditions that allow a species to survive and reproduce. Species potentially affected include juvenile chinook salmon, striped bass, delta smelt, and resident species. These potentially significant impacts may be unavoidable. Implementation under the Preferred Program Alternative, however, would be contingent on development of facility design and operations criteria that have been demonstrated, through monitoring and focused studies, to avoid adverse effects.

Construction of flow control barriers could result in adverse impacts through disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All Delta species could be adversely affected, depending on the timing and location of construction relative to species occurrence. These potentially significant impacts can be mitigated to a less-than-significant level.

Construction of flow control barriers could result in adverse impacts through disturbance of existing biological communities, mobilization of sediments, and input of contaminants.

Hood to Mokelumne River Channel. A pilot diversion structure may be constructed, contingent on avoiding adverse impacts, from near Hood to the Mokelumne River. The intake of the pilot facility on the Sacramento River may include fish screens and a fish ladder or equivalent to provide upstream migrants access to the Sacramento River. In combination with the new channel, the Mokelumne River channel (either the South or North Fork) may be enlarged to increase flow conveyance.

The fish screens potentially prevent juvenile and adult fish from entering the new channel with the flow diverted off the Sacramento River. Downstream of the Hood intake, based on existing flow division relationships, the proportion of Sacramento River flow entering Georgiana Slough (and the DCC, if open) would increase, especially during February to June. Based on existing relationships, operation of the Hood diversion would increase juvenile salmon movement from the Sacramento River into the Mokelumne River channels, reducing their survival. In addition, abrasion, increased predation, and other factors would reduce the survival of fish contacting the fish screens. The diversion could adversely affect winter-, spring-, late fall-, and fall-run chinook salmon and possibly other species (for example, steelhead, splittail, striped bass, and American shad). Implementation under the Preferred Program Alternative, however, would be contingent on development of facility design and operations criteria that have been demonstrated, through monitoring and focused studies, to avoid adverse effects.

A new channel would direct additional Sacramento River water into the Mokelumne River channels and the central Delta. In combination with reduced flow down the Sacramento River channel, migratory species destined for the Sacramento River may be attracted to the Mokelumne River channels and subsequently to Hood. The fish screen at Hood would prevent movement of adult fish into the Sacramento River. Although fish ladders or other passage facilities are proposed, the efficiency of moving fish to the Sacramento River will depend on many factors, including species behavior. Some level of migration delay and blockage is likely, with subsequent adverse impacts on affected populations, including chinook salmon, steelhead, splittail, delta smelt, striped bass, sturgeon, and American shad. Adverse impacts may include mortality, reduced fecundity or reproductive success, and straying—potentially affecting the fitness of natural spawning and rearing populations in appropriated habitats. Implementation under the Preferred Program Alternative, however, would be contingent on development of facility design criteria that have been demonstrated, through monitoring and focused studies, to provide for upstream passage of affected species.

Implementation under the Preferred Program Alternative would be contingent on development of facility design criteria that have been demonstrated, through monitoring and focused studies, to provide for upstream passage of affected species.

The diversion of additional Sacramento River water into the Mokelumne River channels and the central Delta would increase the frequency and magnitude of natural channel net flow direction in the Lower San Joaquin River. Natural net flow conditions in the Lower San Joaquin River channel could increase productivity, enhance species movement, and reduce entrainment in Delta diversions. Species beneficially affected could include chinook salmon, delta smelt, striped bass, and American shad.

To the contrary, diversion of Sacramento River water at the diversion structure would reduce the magnitude of natural net channel flow in the Sacramento River below Hood, primarily during February to June. The minimum flow criteria at Rio Vista and Hood diversion operations criteria would reduce adverse effects. Implementation under the Preferred Program Alternative, however, would be contingent on development of operations criteria that have been demonstrated, through monitoring and focused studies, to avoid adverse effects of a diversion facility near Hood on Sacramento River flow.

If Mokelumne River channel enlargement is the result of setback levees, aquatic ecosystem area is potentially increased. Increased area, if associated with increased riparian and tidal marsh communities, may reestablish natural structural features that could increase productivity and provide habitat for aquatic species. Channel enlargement with setback levees could benefit the aquatic ecosystem and Delta species, although focused studies and monitoring are needed to understand entrainment risk, predation, and habitat use by Delta species. Construction of the levee setback could result in potentially significant adverse impacts through disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All Delta species could be affected in the short term, depending on the timing of construction relative to species occurrence. Mitigation is available to reduce these impacts to less-than-significant levels.

If Mokelumne River channel enlargement is the result of setback levees, aquatic ecosystem area may be increased. Increased area, if associated with increased riparian and tidal marsh communities, potentially reestablishes natural structural features that could increase productivity and provide habitat for aquatic species.

Enlarging Mokelumne River channels by dredging could cause potentially significant adverse impacts. Dredging would increase the channel depth and further alter the natural structural features. In the short term, dredging would remove benthic communities and mobilize fine sediments. Maintenance dredging may be required over the long term, resulting in periodic short-term impacts. Dredging also may cause levee instability, which could require additional revetment and levee maintenance activities. Levee maintenance could remove tidal marsh communities and riparian vegetation. Dredging would adversely affect channel structure, productivity, water quality, and species habitat. Mitigation may be available to reduce these impacts to less-than-significant levels.

Bay Region

The Bay ecosystem would be affected by reduced Delta outflow. Revised upstream facility operations attributable to potential changes in Delta conveyance could increase average annual exports and potentially reduce Delta outflow by about 200-500 TAF relative to No Action Alternative conditions. The simulated reduction in outflow would be relatively small, and adverse impacts are considered less than significant.

Sacramento River and San Joaquin River Regions

Although conveyance facilities and channel modifications are located in the Delta, operations criteria affecting upstream reservoir operations potentially change with implementation of the Delta channel capacity and possible facility elements near Hood. The Delta channel capacity element could allow full use of the SWP export capacity. Simulated hydrology with full use of the SWP export capacity did not noticeably alter reservoir operations or stream flow in the Sacramento River or San Joaquin River Region.

Other SWP and CVP Service Areas

Conveyance facilities under the Preferred Program Alternative most likely would minimally affect fisheries and aquatic resources in the streams, reservoirs, and estuaries in the Other SWP and CVP Service Areas.

Reductions in entrainment at the pumping facilities attributable to improved fish screens could reduce the number of fish, eggs, and larvae that are diverted into the CVP and SWP water systems; and may reduce recruitment to fish populations in canals and reservoirs. These reductions are not expected to significantly reduce fishery resources in the canals and reservoirs supplied by exports.

Reductions in entrainment at the pumping facilities attributable to improved fish screens could reduce the number of fish, eggs, and larvae that are diverted into the CVP and SWP water systems; and may reduce recruitment to fish populations in canals and reservoirs.

6.1.8.2 ALTERNATIVE 1

Impacts in the Bay, Sacramento River, and San Joaquin River Regions, and in the Other SWP and CVP Service Areas would be the same as those described for the Preferred Program Alternative. The impacts associated with a change in Delta channel capacity, modified south Delta intake facilities, and south Delta flow control barriers would be similar to those described for the Preferred Program Alternative, except that unavoidable potentially significant adverse impacts could occur. Alternative 1 would not include a pilot diversion facility near Hood or a change in DCC operations; therefore, conditions in the Sacramento River and Mokelumne River channels would be the same as under the No Action Alternative.

6.1.8.3 ALTERNATIVE 2

Impacts under Alternative 2 are similar to those described for the Preferred Program Alternative, except that adverse impacts attributable to change in Delta channel capacity, south Delta intake facilities, and south Delta flow barriers are potentially significant and unavoidable. Because the capacity of the diversion facility near Hood would be 10,000 cfs, it is likely, given our present knowledge, that potentially significant adverse impacts would be unavoidable. The intake of the facility on the Sacramento River would include fish screens and a fish ladder or equivalent to provide upstream migrants access to the Sacramento River. In combination with the new channel from near Hood to the Mokelumne River, the Mokelumne River channel (either the South or North Fork) would be enlarged to increase flow conveyance. The effects of channel enlargement are similar to those described for the Preferred Program Alternative, except that adverse impacts are potentially significant and unavoidable.

Diversion of Sacramento River water into the Mokelumne River channel could increase mortality of juvenile chinook salmon, block upstream passage through the Hood facility, and adversely affect flow-related habitat conditions in the Sacramento River.

6.1.8.4 ALTERNATIVE 3

Impacts in the Bay, Sacramento River, and San Joaquin River Regions, and in the Other SWP and CVP Service Areas would be similar to those described for the Preferred Program Alternative. Impacts of changes in DCC operations, Delta channel capacity, modified south Delta intake facilities, and south Delta flow control barriers also would be the similar as those described for the Preferred Program Alternative, but potentially significant adverse impacts are likely unavoidable. Impacts of the Mokelumne channel enlargements would be similar to those described under the Preferred Program Alternative. Alternative 3 includes a diversion facility near Hood associated with an isolated facility with a capacity between 5,000 and 15,000 cfs. Revised operations criteria may allow simulated exports to increase by as much as 3% over levels simulated for the Preferred Program Alternative (an average annual increase in exports of 200 TAF) and possibly as much as 10% over the No Action Alternative, intensifying impacts on Delta outflow described for the Preferred Program Alternative. Given the substantial change in Delta flow conditions under Alternative 3, potentially significant unavoidable adverse impacts may occur, although substantial benefits attributable to improved flow conditions in the central and south Delta are also probable.

Isolated Facility. A new isolated 5,000- to 15,000-cfs capacity channel would be constructed from Hood to CCFB. The intake of the facility on the Sacramento River would include fish screens. In combination with the new isolated facility, the south Delta intake, south Delta barriers, and Mokelumne River channel modifications also may be constructed, depending on need relative to flow exported through the south Delta. The impacts of the south Delta intake, south Delta barriers, and Mokelumne River channel modifications would be similar to those discussed above, although the magnitude of impact would be less. With a 15,000-cfs capacity isolated facility, barriers in the Middle River, Grant Line Canal, and Old River near the CVP Tracy fish facility would be unnecessary because overland irrigation supplies would be provided to the south Delta. The adverse impacts on aquatic species that are associated with the barriers would not occur, although impacts associated with the overland irrigation supply would need to be evaluated.

A new isolated 5,000- to 15,000-cfs capacity channel would be constructed from Hood to CCFB. Although the intake of the facility on the Sacramento River would include fish screens, increased diversion-related mortality and effects on flow conditions could result in potentially significant and unavoidable impacts.

The fish screens at Hood would prevent juvenile and adult fish from entering the isolated channel with the flow diverted off the Sacramento River. Downstream of the near Hood intake, the proportion of Sacramento River flow entering Georgiana Slough (and the DCC, if open) would increase. Based on existing relationships, operation of the isolated facility diversion would increase juvenile salmon movement from the Sacramento River into the Mokelumne River channels, reducing their survival. Survival in the central Delta, although lower than for fish remaining in the Sacramento River, may improve in response to seasonal reductions in export from the south Delta. In addition, abrasion, increased predation, and other factors would reduce the survival of fish contacting the fish screens. The diversion could adversely affect winter-, spring-, late fall-, and fall-run chinook salmon and possibly other species (for example, steelhead, splittail, striped bass, and American shad). Given existing level of knowledge about flow and diversion effects, these potentially significant adverse impacts are unavoidable.

The relocation of the intake for SWP and CVP exports from the south Delta to the Sacramento River near Hood would increase the frequency and magnitude of natural channel net flow in the south and central Delta, and in the lower San Joaquin River. The larger isolated facility would substantially intensify natural flow conditions. Although many complicating factors (such as water quality effects) may diminish any benefits of reducing exports from the south Delta, natural net flow conditions potentially increase productivity, enhance species movement, and reduce entrainment in Delta diversions. All species in the south, east, and central Delta would benefit, especially chinook salmon (including juveniles originating from the Mokelumne and San Joaquin Rivers), steelhead, delta smelt, splittail, striped bass, and American shad. The larger the isolated facility, the greater the reduction in flow diverted from the south Delta, and the larger the beneficial impact. Limiting May exports to 5,000 cfs would intensify the beneficial impact for the month of May.

The relocation of the intake for SWP and CVP exports from the south Delta to the Sacramento River near Hood would increase the frequency and magnitude of natural channel net flow in the south and central Delta, and in the lower San Joaquin River. Natural net flow conditions are expected to increase productivity, enhance species movement, and reduce entrainment in Delta diversions, although complicating factors may diminish any benefits.

Diversion of Sacramento River water near Hood would reduce the magnitude of natural net channel flow in the Sacramento River below Hood. The larger capacity isolated facility potentially increases reduced flow. Reduced net flow conditions in the lower Sacramento River could reduce fresh-water habitat (caused by an upstream shift in estuarine salinity in the Sacramento River channel), reduce productivity, and impair species movement (for example, transport of striped bass eggs). Migratory species are potentially adversely affected, including chinook salmon, delta smelt, and striped bass. The Rio Vista minimum net flow requirement of 3,000 cfs and isolated facility operations criteria would limit the magnitude of flow change. Given the current level of knowledge, these potentially significant impacts are unavoidable.

Although the level of increased exports with the new storage elements would be small, the increase could slightly intensify the potentially significant adverse impacts and slightly reduce the beneficial impacts described above. Total Delta outflow also would be slightly reduced because of additional export. The adverse effects of reduced outflow, including effects on estuarine salinity, would depend on the timing and reduction in magnitude relative to base outflow conditions. Given the small change relative to existing flow variability, the impacts are considered less than significant.

6.1.9 PROGRAM ALTERNATIVES COMPARED TO EXISTING CONDITIONS

This section presents the comparison of the Preferred Program Alternative and Alternatives 1, 2, and 3. Given the programmatic level of analysis, what we know of existing conditions, and what we can predict to 2020, the potentially beneficial and adverse impacts from implementing any of the Program alternatives when compared to existing conditions are similar to impacts identified in Sections 6.1.7 and 6.1.8, which compare the Program alternatives to the No Action Alternative.

Although the Program elements common to all alternatives would improve and increase aquatic habitat and improve ecological processes in the Bay-Delta, potentially significant unavoidable impacts are associated with implementing the Conveyance Element under Alternatives 1, 2, and 3. Implementation of strategies to avoid potentially significant adverse impacts on fish populations would be incorporated under the Preferred Program Alternative.

Benefits of the Program alternatives would be less when compared to existing conditions because of the larger difference in increased water deliveries. Relative to existing conditions, additional annual water deliveries under the Program alternatives could range from 0.5 to 1.5 MAF in response to increased demands, new storage, and new conveyance elements (potential increased Delta channel capacity for all Program alternatives and the isolated facility for Alternative 3).

Benefits of the Program alternatives would be less when compared to existing conditions because of the larger difference in increased water deliveries.

Although simulated operations and hydrology indicate similar flow variability for existing conditions and the Program alternatives, increased water deliveries would limit the ability of other Program elements (for example, actions included in the Ecosystem Restoration Program) to reestablish basic hydrologic features necessary to reactivate and maintain the ecological processes and structures that sustain healthy aquatic communities. Adverse impacts could include reduced productivity, reduced species habitat abundance, and degraded transport and attraction conditions. Impacts would depend on the change in flow, timing, and magnitude relative to species occurrence and needs. Additional diversions, including exports, could directly increase entrainment losses and contribute to net Delta flow conditions that may reduce productivity, impair species movement, and increase entrainment in Delta diversions. Most species are potentially affected, including chinook salmon, delta smelt, steelhead, and striped bass.

Although the Water Quality Program would reduce contaminant delivery relative to the No Action Alternative, increased contaminant input under the 2020 level of urban and industrial development for the Program alternatives may exceed input relative to existing conditions. Increased contaminant input could degrade ecosystem processes, reducing system productivity and adversely affecting species growth, survival, and reproduction.

Although the Water Quality Program would reduce contaminant delivery relative to the No Action Alternative, increased contaminant input under the 2020 level of urban and industrial development for the Program alternatives may exceed input relative to existing conditions.

For the Other SWP and CVP Service Areas, additional water deliveries under the Program alternatives may induce municipal, industrial, or agricultural development. Adverse impacts relative to existing conditions would exceed impacts relative to the No Action Alternative and may include greater loss of habitat, increased input of contaminants, and increased disturbance. Disturbance could include disruption of natural hydrology through increased seasonal runoff of applied water, potentially improving habitat for introduced species and adversely affecting native species in streams and estuaries. An accurate assessment of impacts requires detailed site-specific information on the delivery areas, potential for increased development, and vulnerable aquatic resources. Additional analysis will be conducted during environmental documentation for specific projects.

In addition to actions discussed for the Program alternatives, activities unrelated to water deliveries and independent of the Program would be implemented under all Program alternatives and for the No Action Alternative (see Section 6.1.6, "No Action Alternative"). Potential benefits may occur from restoration associated with the Stone Lakes NWR and the SRFCP; improved flow management for the Yuba, Mokelumne, and Tuolumne Rivers; improved management of water temperature conditions in the Sacramento River attributable to the Shasta Temperature Control Device and interim reoperation of Folsom Reservoir; and reduced contaminant input from retirement of agricultural land in the San Joaquin River Region. Benefits could include increased productivity, increased spawning and rearing habitat abundance for riverine and Delta species, and reduced stress from contaminants. Potential adverse impacts may occur from construction associated with various projects, reoperation of Folsom Reservoir, and completion of the Coastal Aqueduct and MWD's Inland Feeder Project. Adverse construction impacts could include disturbance of existing biological communities, mobilization of sediments, and input of contaminants. Reoperation of Folsom Reservoir may reduce summer flows and the flexibility to manage cool-water releases in the lower American River, potentially reducing habitat abundance for steelhead and chinook salmon. Completion of the Coastal Aqueduct and Inland Feeder Project could introduce non-native species, adversely affecting native species communities.

In addition to actions discussed for the Program alternatives, activities unrelated to water deliveries and independent of the Program would be implemented under all Program alternatives and for the No Action Alternative.

6.1.10 ADDITIONAL IMPACT ANALYSIS

Cumulative Impacts. The incremental impact of the Preferred Program Alternative, when added to other past, present, and reasonably foreseeable future actions, could result in cumulative impacts on fisheries and aquatic ecosystem resources. For a summary of cumulative impacts for all resource categories, please refer to Chapter 3. For the list and a description of the projects and programs considered in this analysis of cumulative impacts, please see Attachment A.

Projects and actions that are assumed to be included under existing conditions (Section 6.1.3, "Affected Environment/Existing Conditions") and under the No Action Alternative (Section 6.1.6, "No Action Alternative") were described earlier, along with the discussion of impacts of the No Action Alternative compared to existing conditions. Related past, present, and probable future projects and actions have been evaluated for their potential to contribute to cumulative effects. The cumulative impacts of all of these projects combined with the Preferred Program Alternative are listed below.

In the Delta, Bay, Sacramento River, and San Joaquin River Regions, Program actions and the projects listed in Attachment A would result in cumulative temporary or permanent reductions in seasonal flow and Delta outflow, and potential increases in negative flows in channels leading to the south Delta. Resulting impacts include reduction in habitat abundance and species distribution, impairment of species movement, and increased species entrainment loss. These impacts are either direct or indirect effects of supply management or barrier operation. A cumulative temporary or permanent loss of habitat and removal of benthic communities would result from construction and dredging operations. Habitat restoration activities may cumulatively enhance the productivity of introduced aquatic species to the detriment of native species.

In the Delta, Bay, Sacramento River, and San Joaquin River Regions, Program actions and the projects listed in Attachment A would result in cumulative temporary or permanent reductions in seasonal flow and Delta outflow, and potential increases in negative flows in channels leading to the south Delta.

Although mitigation measures and implementation strategies have been identified that may reduce the impacts for Program actions and projects included in Attachment A, cumulative impacts nevertheless are considered potentially significant.

Changes in operations under the Program and the projects listed in Attachment A are not anticipated to adversely affect fisheries and aquatic ecosystem resources in the Other SWP and CVP Service Areas; therefore, no cumulative effects were identified for this region.

Growth-Inducing Impacts. Increases in exports of water to urban areas in southern and northern California by the Program alternatives could induce municipal and industrial development. Growth may indirectly affect aquatic resources through additional loss of habitat, increased input of contaminants, and increased disturbance. Increased input of urban and industrial contaminants would increase stress on biological processes (for example, reduced organism growth and fecundity, and increased organism susceptibility to disease) and would adversely affect species population distribution and abundance. Disturbance could include alteration of species habitat structure and disruption of natural hydrology through increased seasonal runoff from rainfall and applied water. Habitat conditions may be improved for introduced species, potentially affecting competition with native species for limited resources. The nature of the effects would depend on where economic or population growth occurred and how it was managed.

Projected growth is expected to result in large-scale conversion of agricultural lands to urban and residential uses, independent of any proposed Program actions.

Depending on the effectiveness of the Program, improved quality of the aquatic environment and increased fish species abundance may enhance recreational and aesthetic values. While these improvements definitely would increase the attractiveness of the Program study area to current and future residents, they will not attract population growth to a similar degree that factors such as desirable and plentiful jobs, good socioeconomic conditions, and affordable housing will. While important, the number of jobs available in the recreational and commercial fishing, environmental, and scientific sectors (that might be influenced by improvements to habitats and fish populations) are likely dwarfed by those in the industrial, commercial, and agricultural sectors.

Short- and Long-Term Relationships. Adverse short-term impacts on fisheries and aquatic resources are primarily related to construction activities. Their adverse effects, however, would be avoided, minimized, and mitigated as described previously, to the maximum extent possible. Implementation of BMPs, including a stormwater pollution prevention plan, a toxic materials control and spill response plan, and a vegetation protection plan would avoid and minimize most construction impacts. Limiting construction activities to windows of minimal species vulnerability would further avoid and minimize impacts. When impacts cannot be avoided or minimized, off-site development of comparable resources to at least an equivalent level may be required and may include Program actions contributing to long-term productivity through habitat restoration or facility construction.

Implementation of BMPs, including a stormwater pollution prevention plan, a toxic materials control and spill response plan, and a vegetation protection plan would avoid and minimize most construction impacts.

Long-term ecological benefits is a primary objective of the Ecosystem Restoration Program. Implementation of the Ecosystem Restoration Program Plan within the guidelines of the Strategic Plan would ensure that design principles and criteria that affect fisheries and aquatic resources are selected on their ability to avoid short-term adverse impacts and to enhance and maintain long-term productivity. Selection of design principles and criteria for other resource plans, including the Levee System Integrity, Water Quality, Watershed, Storage, and Conveyance Elements, that would affect fisheries and aquatic resources also would be based in part on their ability to avoid short-term adverse impacts and to enhance and maintain long-term productivity.

Flow conveyance facilities and operations can result in potentially significant adverse short-term impacts. The intensity of impacts increases from Alternative 1 through Alternative 3. Impacts for the Preferred Program Alternative would be avoided. The difference in intensity is due to reliance on larger facilities, greater changes in Delta channel structure, and change in facility location. The increasing structural and operational changes under Alternatives 2 and 3 and, possibly, the Preferred Program Alternative, however, provide the opportunity for increased enhancement of long-term productivity relative to Alternative 1.

Irreversible and Irretrievable Commitments. Implementation of the elements included in the Program alternatives would result in some irreversible and irretrievable commitments of existing aquatic resources. Planned reestablishment of aquatic habitat types included in the Ecosystem Restoration Program would be difficult, if not impossible, to fully reverse once construction had commenced. After species communities are established, it would be even more difficult to restore preexisting conditions. Constructed components of the Storage and Conveyance elements, and the Levee System Integrity and Watershed Programs also could result in irreversible and irretrievable commitments of existing aquatic resources. The most significant commitment would occur in cases where aquatic ecosystem structure and connectivity is altered by reservoirs, levees, or conveyance facilities.

Planned reestablishment of aquatic habitat types included in the Ecosystem Restoration Program would be difficult, if not impossible, to fully reverse once construction had commenced. After species communities are established, it would be even more difficult to restore preexisting conditions.

Irreversible and irretrievable commitments of aquatic resources, however, would be contingent on avoiding and minimizing adverse impacts through completion of screening and prioritization processes that incorporate:

- The best available understanding of natural physical and ecosystem processes and species habitat needs.
- Progressive implementation of Program elements over the long term.
- Integrated monitoring, research, and evaluation to assess achievement of the Program objectives and conformance to solution principles.

Activities would proceed based on confidence in the desirability of the results. Adaptive management would be employed during implementation of actions to allow early detection and minimization of undesirable results. In addition, mitigation measures would be employed to minimize any adverse impacts of such commitments.

Adaptive management would be employed during implementation of actions to allow early detection and minimization of undesirable results.

6.1.11 MITIGATION STRATEGIES

These mitigation strategies will be considered during specific project planning and development. Specific mitigation measures will be adopted, consistent with the Program goals and objectives and the purposes of site-specific projects. Not all mitigation strategies will be applicable to all projects because site-specific projects will vary in purpose, location, and timing.

Mitigation strategies proposed in this programmatic document are conceptual in nature. Final mitigation measures would need to be approved by responsible agencies as site-specific projects are approved by subsequent environmental review.

The impact assessment for fisheries and the aquatic ecosystem is based on currently available information. Detailed information on Program actions or responses to the actions are sometimes unavailable. Because of the uncertain results of actions affecting the ecosystem, Program actions will be implemented through adaptive management. Adaptive management includes an identification of the indicators of ecosystem health; phased implementation of substantial project actions; comprehensive monitoring of the indicators; and a commitment to remedial actions necessary to avoid, minimize, or mitigate immediate and future adverse impacts of project actions on ecosystem health.

Because of the uncertain results of actions affecting the ecosystem, Program actions will be implemented through adaptive management. Adaptive management includes an identification of the indicators of ecosystem health; phased implementation of substantial project actions; comprehensive monitoring of the indicators; and a commitment to remedial actions necessary to avoid, minimize, or mitigate immediate and future adverse impacts of project actions on ecosystem health.

The following potential mitigation strategies are proposed:

- Implementing BMPs, including a stormwater pollution prevention plan, toxic materials control and spill response plan, and vegetation protection plan.

- Limiting construction activities to windows of minimal species vulnerability.

- Creating additional habitat for desired species, including increasing aquatic area and structural diversity through construction of setback levees and channel islands.

- Controlling undesirable non-native species.

- Operating new and existing diversions to avoid and minimize effects on fish (that is, avoiding facility operations during periods of high species vulnerability). The operational changes could reduce water availability for other beneficial uses identified in Section 5.1, "Water Supply and Water Management."

- Relocating the diversion point to avoid primary distribution of desired species.

- Controlling predators in the diversion facility (screen bays) and modifying diversion facility structure and operations to minimize predator habitat.

- Constructing a barrier to fish movement on Georgiana Slough. Adverse impacts of a flow barrier, however, would need to be considered (that is, reduced flow in the lower San Joaquin River), although benefits could occur if implemented concurrent with reduced south Delta exports. To date, effective fish barriers that could reduce the impact of increased movement from the Sacramento River with minimal flow effects have not been developed.

- Coordinating and maximizing water supply system operations flexibility consistent with seasonal flow and water temperature needs of desired species.

6.1.12 POTENTIALLY SIGNIFICANT UNAVOIDABLE IMPACTS

Incomplete knowledge of species needs and unpredictable responses to restoration actions may adversely affect some species and cause potentially significant unavoidable impacts. Avoiding, minimizing, and mitigating potentially significant adverse impacts depends on developing knowledge of species needs and understanding of the project actions, and can be assured only through implementation programs that include adaptive management. The adverse impacts identified below potentially limit restoration options and success discussed for other elements of the Program Alternatives.

Incomplete knowledge of species needs and unpredictable responses to restoration actions may adversely affect some species and cause potentially significant unavoidable impacts.

Potentially significant and unavoidable adverse impacts include:

- In response to habitat restoration, non-native species abundance and distribution may increase to levels detrimental to native species.

The following potentially significant and unavoidable impacts of the Preferred Program Alternative on fish and aquatic species populations would be avoided through adherence to the Program implementation strategy discussed in the text. However, individuals of special-status species may experience unavoidable impacts.

- Placement of barriers in the south Delta may block access to habitat and potentially alter water quality and flow conditions.

- Effects of water supply management and facility operations on flow, salinity, and water temperature potentially reduces habitat abundance, impairs species movement, and increases loss of fish to diversions.

- Change in DCC operations and south Delta barriers potentially reduces frequency and magnitude of net natural flow conditions in the south and central Delta, potentially reducing system productivity, impairing species movement, and increasing losses to diversions.

- The pilot diversion near Hood potentially reduces net flow conditions in the Sacramento River downstream of Hood, potentially reducing fresh-water area and impairing species movement and survival.

- The new fish screen facility for the through-Delta and isolated facility elements on the Sacramento River potentially increases fish mortality through abrasion, increased predation, and other factors.

- The fish screens and diversion facility on the through-Delta element potentially delay migration and reduce spawning success for adult fish moving from the Mokelumne River channels into the Sacramento River.

Although potentially significant unavoidable adverse impacts have been identified, the Program has committed to avoiding potentially significant adverse impacts on fish populations. Program elements would be constructed and operated only after implementation strategies are developed that will avoid potentially significant adverse impacts on fish populations.

Although potentially significant unavoidable adverse impacts have been identified, the Program has committed to avoiding potentially significant adverse impacts on fish populations. Program elements would be constructed and operated only after implementation strategies are developed that will avoid potentially significant adverse impacts on fish populations.